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symposium on growth and development of maize in the
Latin Americas*

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Plant research in the tropics: A symposium on growth and development of maize in the Latin Americas

I. E. Melhus
Iowa State College

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RESEARCH
BULLETIN 371

PLANT RESEARCH IN THE TROPICS

• • •

EDITED BY I. E. MELHUS

A Symposium on Growth and Development of
Maize in the Latin Americas.

Researches Emanating from the Iowa State College-
Guatemala Tropical Research Center.

Official Opening of the Center at Antigua, Guatemala, C. A.

AGRICULTURAL EXPERIMENT STATION, IOWA STATE COLLEGE
AMES, IOWA

DECEMBER, 1949

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The drawing on the cover is adapted from a carving on a stone monument found in Guatemala. It represents the Maize-god in the symbolic act of scattering corn. This particular monument was erected in front of the Mayan Temple at Piedras Negras, Guatemala, in the year 746 A.D., and is to be seen in the University of Pennsylvania Museum where it has been loaned by the Guatemalan government.

Iowa State College-Guatemala Tropical Research Center

The Tropical Research Center is an outpost of the Iowa State College located at Antigua, Guatemala, in tropical America. This outpost was organized for research and graduate study in agriculture and the natural sciences by The Iowa State College and approved by the State Board of Education in December, 1945. The Iowa State College believed that to improve the service which plants give to man, it would be desirable to study plants of other climates comprising areas known to be centers where nature and the primitive man cooperated to bring so many of our crops into existence. The College believed too that a station in the tropics would facilitate the solution of its problems in the natural sciences, which are basic to all technology. And lastly the Tropical Research Center was created in order that the College might broaden and liberalize the training and thereby increase the usefulness of its staff and graduate students by affording them an opportunity to work and study in the tropics where the plant, animal and human environment are very foreign to our own. All of this was made possible largely through a grant of money from a public-spirited citizen of Iowa, the late Earl E. May. The work of the Center was initiated in February, 1946, with headquarters in Antigua, Guatemala, where laboratories, offices and trial grounds have been established in sympathetic cooperation with public-spirited citizens of Guatemala engaged in private enterprise and with the Guatemalan Government.

I. E. Melhus, Director
Iowa State College-Guatemala
Tropical Research Center

Work of the Tropical Research Center is conducted in cooperation with
The Iowa State College and the Guatemala Ministry of Agriculture .

Tribute to the Late Earl E. May

Earl E. May was born in a farm home near the town of Hayes Center, Neb., March 21, 1888. As a young man he entered the State University Law school, earning most of his college expenses. One of his summer jobs, selling seeds for the D. M. Ferry Company, fired his imagination. Later he saw these dreams come true as he developed a successful business enterprise built on solid principles and service to the people of the land.

Earl May was richly endowed with the spirit of service to his fellow men. He had a clear searching mind that understood the present and projected his thinking into the future. He had the rare ability of translating and integrating his thinking, experiences and observations into service for the people who came within his sphere of activity. This was apparent by the many awards bestowed upon his radio station¹ which carried the voice of his sincerity and desire to help people in all walks of life.

But Earl May was not a man to be satisfied with serving people for the present. He gave much thought to the future, not for his own business alone, but also for the betterment of agricultural conditions generally.

In his travels in many parts of the United States and several foreign countries, the agricultural conditions interested him. The following incident illustrates the nature of his inquisitive mind. Once in Mexico he had occasion to explore the Aztec ruins where he saw an ear of corn more than a thousand years old. It was not the state of preservation, color, size or shape that interested him most, rather it was the more hidden aspects, such as the appearance of the plant that bore the ear and what characters, if any, this early corn had that might enhance the corns of the corn belt and the rest of the world. This agile mind and innate desire to serve people led Earl May to establish a grant-in-aid for basic research at Iowa State College. Through this grant, the College was able to set up an outpost for basic research in the natural sciences and agriculture in the tropics of middle America at Antigua, Guatemala.

A kind and considerate man, Mr. May was keenly interested and active in the cultural, civic and religious life of his community. He was also devoted to his family—his wife and two children, Edward and Frances.

¹Radio Station KMA, Shenandoah, Iowa.



THE LATE EARL E. MAY

The story of Earl May's accomplishments would not be complete without a word about his wife, Gertrude Welch May, a charming, talented woman. Mrs. May contributed untiringly of her talents and energy to the growing seed business and radio broadcasting station. She found time to serve society not only in her home community, but also throughout the state and nation.

This publication which includes the exercises comprising the official opening of the Iowa State College-Guatemala Tropical Research Center on March 6, 1948 is respectfully dedicated to the memory and honor of the late Earl E. May.

—I. E. Melhus

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¹Advisory council as of 1947-48.

Symposium: Growth and Development of Maize in the Latin Americas

Some Recent Aspects of Mayan Civilization and Maize Culture on the Pacific Coast of Guatemala

BY EDWIN M. SHOOK
CARNEGIE INSTITUTION OF WASHINGTON

It is noteworthy that here in Antigua, the old capital and seat of learning of the Spanish Colonial Kingdom of Guatemala, a new institution of research should be inaugurated. That the principal effort of the Iowa State College Tropical Research Center be the investigation of maize stimulates one to emphasize that this great food staple was given to the world by the American Indian. Many groups of aborigines throughout the Americas rose from low stages of culture to the higher attainments of civilization because of Indian corn. One of those groups, the Maya, flourished in Guatemala for some 2,000 years and its history is one of a progressive cultural evolution based upon agriculture—chiefly maize. The Spanish conquest of Guatemala in 1525 A. D. and the eventual founding of Antigua as a capital may be said to have resulted from the domestication of the maize plant.

Such a comprehensive statement needs further explanation. Most students of aboriginal American history cling to the theory that the Western Hemisphere was populated by small successive bands moving out of Asia across the Bering Straits, despite the recent successful transoceanic jaunt across the South Pacific on a balsa raft. It is uncertain if the first Asiatic arrivals reached the New World during one of the interglacial stages. It is quite certain, however, that toward the close of the last glacial period, some 25,000 years ago, man penetrated the continent of North America. Having come from regions of northeastern Asia into which no elements of higher civilization penetrated until very recent times, these immigrants could have brought with them no knowledge of these elements. The movement of man in America is visualized as a slow meandering southward, the earlier arrivals being pressed forward by later comers, all, we believe subsisting on game, fish, and whatever wild plant products the particular locality provided. In that low stage of culture they gradually populated the entire extent of both continents. It is believed that no influence from the Old World reached them in subsequent times and therefore that New World civilizations were independently developed. Remains of these early hunting, food-gathering people have been found in association with now extinct fauna over much of the United States, recently in the Valley of Mexico, possibly in Nicaragua, and sporadically in South America. The greater frequency of the finds in



Fig. 1. Highland village of San Miguel Ixtahuacan, Department of San Marcos, Guatemala, elevation 6,600 feet, showing agricultural terraces and corn fields after harvest of single crop, Oct. 27, 1946.

the United States may be due to the intensity of research and to the more favorable geological exposures. No traces of early man have

been discovered in Guatemala, but once systematic search begins I believe they will be found. Geographically, Guatemala sits astride the migration route of early man, as do the other Central American countries. The problem is made difficult by the incredible amount of geologically recent volcanic activity which covers the older strata throughout these countries. In Nicaragua, human footprints have been exposed in a now solidified volcanic mud flow which Dr. Howell Williams, of the University of California, conservatively dates five thousand years ago. Only a short strip of rock has been exposed showing the bare footprints of 17 individuals making a bee-line for a small peninsula in Lake Managua, very likely to seek safety from the volcanic eruption taking place



Fig. 2. Preclassic period modeled pottery jar. Usulután ware, height 15 centimeters. From Las Trosas on Pacific Coast, south of Tiquisate, Department of Escuintla, Guatemala. Francisco Aldana Collection.



Fig. 3. Preclassic period pottery figurine from Chanchicupe above San Pablo, Department of San Marcos, Guatemala. The female figurine is solid, hand-modeled, slipped cream, with headdress painted red and other details black. Height 20.2 centimeters. Guatemala National Museum.

at their rear. Tracks of modern animals, peccary, otter, a lizard and a large bird, impressions of twigs and leaves of modern plants also occur in an excellent state of preservation in the rock. The chances are good that by tracing the human footprints to their source one would find a small village site with imperishable implements and household furnishings and casts of all impermanent objects. Were these ancient Nicaraguans maize agriculturists in a settled community or were they still hunters and fishermen at a temporary campsite?

Again, it must be emphasized strongly that up to the present time no evidence of early man has been found in Guatemala, but of even



Fig. 4. (Left) Early Classic period deeply incised cylindrical tripod vase. Pinkish-cinnamon Tiquisate ware, height 13.2 centimeters. Found in Ixtepeque Farm, Tiquisate, Department of Escuintla. Pinata Collection.

Fig. 5. (Center) Early Classic period modeled jar. Esperanza Flesh ware, height 18 centimeters. From Mound 0-17, Toliman Farm, Tiquisate. Francisco Aldana Collection.

Fig. 6. (Right) Late Classic period cylindrical vase with two opposite mold-made decorative panels. Tiquisate ware, height 16.8 centimeters. From Ixtepeque Farm, Tiquisate. Guatemala National Museum.

more importance relative to the origin and domestication of corn, no remains of a really early agricultural people.

Knowledge of the preconquest history in this area, as elsewhere in the Americas, although far from being complete has increased steadily. Our oldest horizons have been called archaic by some authorities principally because of rather crude appearing hand-modeled clay figurines which are found in association with the earliest material. However, Dr. Vaillant's intensive stratigraphic investigations in the Valley of Mexico with particular stress on the archaic horizon first brought out the fact that this culture was surprisingly well developed. Subsequent studies have amplified the picture. We now know that the so-called archaic remains are those of a people on a high plane of civilization. They had already achieved a social organization with a stable theocratic government under which enormous public works were carried out. They had a secure economy based upon agriculture, maize being the food staple. Cotton was grown and woven on the loom. Industries flourished. They made excellent pottery, baskets, mats, tools of flint and obsidian, stone metates and manos for grinding corn, and they produced a respectable quality of sculpture in stone. Such progress could only have been the result of a long period of growth. The tremendous gap existing between the simple wandering hunters and fishers and these people is the problem-cud on which we are continually chewing. The answer may be forthcoming through further systematic research, particularly in the archeologically unexplored regions of Mesoamerica.

One of the objectives in Carnegie Institution's archeological survey of the south coast of Guatemala was to search diligently for evidence of the early Mesoamerican farmer. The narrow 30-mile-wide, rela-

tively low lying, coastal plain between the Pacific Ocean and the foothills of the paralleling volcanic chain is a natural corridor along which people have moved since man's first entrance into this area. The Pacific coastal plain consists of sands, gravels and clays, predominately of fluvial origin, making an extremely fertile soil. The annual temperature is high, and the zone has sharply defined wet and dry seasons, the rainfall occurring almost entirely during the months from May to October. Despite the lack of rain during the dry season, the coast plain is well watered by innumerable streams which cross it. With the exception of a small zone around Santa Lucia Cotzumalguapa, little attention had been given to the Pacific coastal area by archeologists previous to the survey. Work began near the Mexico-Guatemala frontier and plans are to continue as far as the Salvador border. Although the investigation has only just begun, certain facts are already obvious. The area is one of the most archeologically rich of any in Mesoamerica. Vast ruins of ancient cities, as well as of smaller villages, line the banks of the rivers and streams at short intervals from the foothills of the volcanoes to the Pacific beach. Some sites, as at Tiquisate in the western part of the Department of Escuintla, are aligned along the course of an old streambed, showing that at the time of occupation a river existed. The same river jumped its course and joined another to the west, leaving these towns stranded without a readily available water supply. This may have caused their abandonment. Other cities where no evidence was noted of the shifting of water courses were in some cases built up in one period, abandoned for centuries, then reoccupied by people presumably completely foreign to the original builders. The whole history of the Pacific coast is complicated and awaits much more intensive study, but at least a start has been made.

Occupation was heavy from the so-called Archaic period, which will be referred to hereafter as the Preclassic, tentatively dated from 500 B. C. to 300 A. D., through to the time of the Spanish conquest. The Classic period from 300 to 900 A. D. was the brilliant era of the Maya when in certain areas, particularly the lowlands on the Atlantic side of Guatemala, they carved their inscriptions on



Fig. 7. Late Classic period life-size human head modeled in red pottery, broken from a complete figure. Maximum height 31 centimeters. From Esquipulas Farm, Tiquisate. Head supported by stone fiber or bark beater. William M. Palmer Collection.

stone monuments and raised such spectacular architectural works as the pyramids and temples of Tikal and Copan. On the Pacific coast, the Maya were also thriving but due to lack of sufficient quantities of lime and suitable stone for building purposes their edifices have not withstood the elements as well as those of Peten. Toward the end of the Classic period and periodically through Postclassic times from 900 to 1525 A. D. there were here, as everywhere in Mesoamerica, severe stresses on the coastal cultures. Some areas were abandoned, possibly rendered untenable by pressure of invading Nahua from Mexico. We do know these people pushed southward along the Pacific coast and eventually settled in the region now encompassed by the Department of Escuintla and at the time of the Spanish conquest the present town of Escuintla was the capital of the Pipil Indians, a Nahuatl-speaking people. That the Pacific coast should have been occupied from early times is not surprising. It is admirably suited to corn cultivation. Two successful crops are harvestable each year. Cacao and cotton were other important agricultural products. Salt, so important to all human beings, was extracted from sea water. Game, fish and fruits of the tropical forest remained plentiful, making life easier on the coast.

It is my theory that the earliest agriculturists in Guatemala lived along the coastal plain, and as the population increased and more land for cultivation became necessary, they slowly pushed into the highlands along the natural means of access, the river valleys, to the broad plains behind the cordillera such as the Antigua.

Algunos Aspectos Recientes Sobre La Civilización Maya, Y El Cultivo Del Maíz En La Costa Del Pacífico En Guatemala

RESUMEN

POR EDWIN M. SHOOK

CARNEGIE INSTITUTION OF WASHINGTON

Es digno de notarse el hecho de que aquí en Antigua, la capital antigua del reino colonial de Guatemala hubiera de establecerse el Iowa State College, Guatemala Tropical Research Center; y el hecho de que dicha institución se interese más en las investigaciones sobre el maíz, estimula en uno el deseo de recordar que este alimento fué legado al mundo, por el indio americano. Los Mayas florecieron en Guatemala durante unos 2000 años, y su evolución cultural estaba basada en la agricultura y especialmente en el cultivo del maíz.

Se sabe ciertamente que el continente americano comenzó a ser poblado, hacia el final del último período glacial por el hombre proveniente del Asia Norte-oriental, el que no traía consigo ningún elemento de civilización y se alimentaba con lo que la fauna y flora sal-

vajes le ofrecían. De aquí surgieron las civilizaciones occidentales sin más aportación del viejo mundo.

En Guatemala no ha sido posible encontrar restos del hombre primitivo; pero es casi seguro que puedan encontrarse indicios de su existencia en estos lugares al acrecentar las investigaciones necesarias. En Nicaragua se han descubierto huellas de pies desnudos de hombres que se cree hayan existido hace 5000 años. ¿Cultivaban el maíz estos antiguos hombres, o todavía vivían de la caza y los productos de la naturaleza?

Los restos más antiguos en el valle de Méjico indican que la civilización de esos tiempos era ya immensamente avanzada: El problema de hoy es el de establecer el curso de la evolución del hombre americano primitivo, hasta tal grado de civilización.

Como se dijo anteriormente, no hay evidencia que indique la existencia de un pueblo agrícola antiguo, en Guatemala. Precisamente el objeto de la exploración de la Carnegie Institution, en el litoral del Pacífico es el de hallar indicios que nos conduzcan a establecer su existencia. Se considera que este litoral es una de las regiones más ricas arqueológicamente, en Centro América. En efecto los Mayas ocuparon esta región primeramente por razón de las admirables condiciones que para el ejercicio de la agricultura reinan en esta comarca; es de notar que aquí es posible producir dos y hasta tres cosechas de maíz al año. De aquí emigraron a las tierras altas y a los valles allende la cordillera, conforme fué necesario; aquí florecieron las industrias de alfarería, y textiles, así como la fabricación de herramientas de obsidiana y pedernal.

Estas regiones de Centro América y Méjico, y el lado del Atlántico no deben eliminarse como posibles lugares de origen de la agricultura americana, ni aún del maíz, ya que se sabe que la más grande civilización aborígen, la de los Mayas, ocurrió en las húmedas y cálidas tierras del trópico.

Corn in Guatemala

By H. M. SIERRA

DIRECTOR GENERAL DE AGRICULTURA DE GUATEMALA

The cultivation and distribution of corn in Guatemala have special importance because it was here that this cereal probably originated. Indians, descendants of the ancient Mayas, cultivate most of the million acres of corn grown annually in Guatemala at altitudes ranging from sea level to 10,000 feet. There are hundreds of varieties, if one may designate as varieties the many classes of corn that exist here in the different climatic zones. Just around Huehuetenango, which approximates New Jersey in size, there are more than 80 varieties. These varieties, or classes, of corn sometimes differ very little from each other in some characters, but on cultivating them one can distinguish differences in their resistance to heat, frost, borers, diseases, soil requirements and so on. Guatemalan corns form an encyclopedia

of corn, waiting to be put down in order. These corns are profusely distributed in fertile valleys, on mountain tops and on hillsides sometimes having slopes of 75 percent.

The Indians consider it an indispensable part of their existence to cultivate corn with their own hands, to the extent that even if they were given the amount of corn necessary for their tortillas or pancakes, they would still plant corn according to their traditions, which are intimately related to their religion. The religion is primarily Catholic, influenced in various cases by the Indian traditions of each different community. The Indian, then, is the real corn grower of Guatemala, and he lives entirely from the soil, his only implements being the machete at his belt and the hoe in his hands. Naturally, there are many distinct types of Indian communities, speaking different languages. In some of them are seen certain tendencies towards modern ways of living. In general, it may be said that there are as many differences between communities as between the kinds of corn they grow.

The total production of corn in Guatemala is calculated at about 12 million bushels, which signifies an average of 12 bushels per acre. If we compare this with production records in the United States, we see that it is very low, the chief reasons being the latitude and methods of cultivation. Corn is grown in Guatemala, with a few exceptions, just as it was hundreds of years ago. The first corn growers who lived here had to raise almost superhuman efforts to obtain crops free from the ravages of wild animals, insects, diseases and weather, but they did it and saved for us a legacy which is comparable only with the legacy of wheat from the banks of the Euphrates in Asia Minor. Today, these same plagues continue to damage the crops but the varieties of corn used are more resistant. Even though there are means today of reducing damage, the Indians do not yet possess these means. The Ministry of Agriculture nurtures the project of supplementing the crops raised by the Indians, with the product of extensive areas, where corn will be grown by modern methods, including the control of diseases, insects and erosion, just as in the United States. These areas are on the Pacific coast and are very fertile and of great size.

In these areas in the future, corn maturing in 90 days will be used and three crops a year will be obtained, giving 150 bushels per acre per year. Today the small Indian plantings in the same region give three crops a year, but the varieties are poor and they produce very little.

The United States, the Ukraine and the Danube possess an ideal time of year for the cultivation of corn; the days are long, the soils are fertile and there are not too many plagues to combat. Last year hybrid corn from the United States was tried out by several hundred Guatemalan farmers in order to get increased production, but the result was a failure, principally because the days are so short here that the corn did not receive sufficient light for the elaboration of food in the leaves. Other North American varieties produce corn, but only on crossing with native varieties do they show any improvement. Guate-

mala puts great hopes, as regards corn, in the Iowa State College-Guatemala Tropical Research Center, where hundreds of experiments are in progress. I, personally, am of the opinion that not only Guatemala, but the United States, also, will receive great benefits from this work, which was started, thanks to the clear vision and philanthropy of Earl May of Shenandoah, Iowa, who provided funds which made the Research Center a reality. Probably it will require some years before the fruits of this effort are seen, but I am confident, just as all Guatemalans, that the work will prosper because it is in the hands of Iowans and that signifies men of faith, accustomed to struggle. You may be sure that the terrible European corn borer will have to sharpen its mandibles if it wants to feed on the new corn varieties that will come out of the Iowa-Guatemala Research Center.

As has already been explained, there are very few countries in the world that possess the conditions that are found in Guatemala as regards corn. Right here, in the middle of the twentieth century, we see a replica, with few modifications, of the way the primitive inhabitants of America cultivated corn. Before modern civilization, with its progressive methods, changes this situation, science ought to take advantage of this fertile field which can give much to the world today hungry for the corn that will resist climate and plagues and be highly productive. Who knows but what this same land will give the key to deciphering the secret of the origin of corn, a secret just as important as that of the origin of man on the American continent.

As has been seen, there is a great difference between the cultivation of corn in the United States and in Guatemala. For example, there is no snow in any part of Guatemala and the plagues multiply all year long. There is also a great difference between the North American grower of corn and the native of Guatemala who raises corn. The North American more or less calculates his profits or losses before he plants his corn, whereas the Guatemalan Indian does not even bother about where or how he plants his corn, his chief object being to have corn planted that he can take care of as tenderly as a father cares for his children. He does not calculate costs such as those of clearing the land, preparing the land, cultivating the field, and does not even take into consideration how long it takes to reach his field nor how difficult it is. When he has obtained his crop, he does not even stop to think about the 30 or 40 miles he has to walk with 2 bushels on his back to reach the market. Once at the market he just sits and waits, no matter how long, until someone buys his corn. If the same system were used in the United States corn would have to bring \$70.00 a bushel, yet the actual cost of a bushel of corn in Guatemala is \$1.25—less than one-half of what it is in the United States. Naturally there is a difference between the standard of living in the two countries when the native of Guatemala loses so much economically using this kind of production methods, but if we view the problem from the philosophical point of view of the Indian, we see that the objective of man's struggle is his own happiness and that of his children. The Indian is rooted to the soil in which he lives,

whether nature is kind or wild and unruly. To destroy or disorganize brusquely his way of life is impossible. Gradual changes can be made and that is precisely what is being done in Guatemala by educational methods, in schools, army posts and by ambulatory missions. The Indian is happy when he grows corn, even though what he calls happiness is to us misery.

El Maíz En Guatemala

RESUMEN

POR H. M. SIERRA

DIRECTOR GENERAL DE AGRICULTURA DE GUATEMALA

El cultivo del maíz tiene especial importancia en Guatemala por creerse que aquí fué su lugar de origen, y por la existencia de numerosas variedades del mismo, las cuales pueden contarse por cientos, distribuidas en el territorio de la república desde el nivel del mar hasta diez mil pies de altura.

La mayor parte de la extensión sembrada de maíz en Guatemala, es cultivada por los indios actuales quienes consideran dicho cultivo como parte integrante de su propia vida.

La producción total de maíz en Guatemala se estima en unos 12,000,000 de bushels lo que representa el bajo promedio de 12 bushels por acre, lo que puede explicarse al considerar que en Guatemala se cultiva el maíz como se hacía hace varios siglos; es decir con herramientas anticuadas y sin el auxilio de la ciencia agrícola.

Hoy en día sin embargo, el Ministerio de Agricultura trabaja en el proyecto de suplementar la producción, con maíz cultivado en grandes extensiones de la costa del Pacífico, donde se emplearán métodos modernos.

En Guatemala se han hecho varias pruebas con híbridos de los Estados Unidos los cuales no produjeron los altos rendimientos que les eran atribuidos, por razón de la diferencia de clima, como consecuencia de la marcada diferencia de latitud existente entre los dos países.

Deseamos expresar nuestra esperanza que ha despertado en nosotros la institución del Iowa State College, Guatemala Tropical Research Center, cuyos trabajos se encaminan al mejoramiento del maíz y cuyos frutos habremos de aprovechar con el correr del tiempo.

The Development of Hybrid Corn in Iowa

BY EDWARD MAY

PRESIDENT OF THE MAY SEED COMPANY

Certain definite, natural laws governing the inheritance of plant characteristics were discovered in 1865 by Mendel, an Austrian monk. The results of his experiments and scientific research were pub

lished the following year. These are now known as Mendel's laws of inheritance. The practical application of these laws in corn research was begun in 1900. The ultimate result was hybrid corn. It is considered to be the most important and far-reaching contribution to agriculture since the invention of the steel plow. Hybrid corn has greatly increased farm income in the corn-producing states and contributed billions to the economic welfare of the nation.

During the 30 years following the rediscovery of Mendel's classic work in 1900, many methods were tried in applying his principles of heredity to corn research. Little progress in increasing yields was made by the original investigators, but they accumulated a great deal of knowledge on the genetics of corn. These geneticists also developed pure lines of corn, so that for the first time other workers could repeat their experiments.

It remained for George H. Shull to effectively apply Mendel's discoveries to corn when he produced the first hybrid by crossing two inbred strains. Too, Shull first recognized fully the real potentialities offered in hybrid corn. Edward M. East contributed a wealth of knowledge on the effects of inbreeding and cross breeding, affording a foundation for hybrid corn as we now know it. However, it was Donald F. Jones who harnessed hybrid vigor in a way that it could be utilized in practice. This came with Jones' double cross in 1917.

But there was still a big gap between the discovery of the double cross and the commercial production of hybrid seed corn. However, the solid scientific foundation soon brought recruits to the cause of utilizing Jones' new technique, the double cross.

Among the recruits in Iowa was Henry Wallace, a former vice president of the United States. He did much to promote the scientific and commercial aspects of hybrid seed corn. He worked patiently and long in applying the principles discovered by Shull, East, Jones and others. Wallace was definitely a pioneer in industrializing the use of hybrid seed corn in Iowa.

In 1922 the United States Department of Agriculture launched a well developed hybrid corn research program in cooperation with several of the agricultural experiment stations in the corn belt. This permitted the initiation of a strong program in Iowa, largely through federal support. Basic germ plasm was isolated from 16 high yielding, open-pollinated varieties. Methods of obtaining useful, pure lines were not as efficient as those of the present day, so that no combinations were ready for distribution from the Iowa station until 1932.

The first commercial hybrid seed produced and sold in Iowa began in 1924 when the Iowa Seed Company of Des Moines offered Copper cross, one of Wallace's hybrids, for sale in limited quantities at \$1.00 per pound to Iowa farmers. Wallace's faith in the future of hybrid seed corn led to his organizing the first company in Iowa devoted exclusively to the development and sale of hybrid seed corn.

Henry Wallace's sterling qualities as a man and budding public servant were recognized by President Roosevelt, and in a short time

Wallace had to entrust his hybrid foundation stocks and newly founded company to his associates. The Pioneer Seed Company has flourished and today is performing a valuable service to the hybrid seed corn industry of the corn belt of the United States.

Richard Crabb¹ summarizes very well the role of private enterprise in the hybrid seed corn industry: "The long years of work done carefully, brilliantly, and patiently by East, Hayes, Jones and all the other hybrid-corn makers would have come to little or nothing had not the often discussed system of private enterprise stepped in and matched, in a sense, the genius of the corn breeders by raising up a new industry to convert the fruits of their research into something corn farmers could use. This new industry invested the resources and took the risks involved in a quick building of a new business, so that in a remarkably few years the benefits of the new kind of corn were spread to farmers scattered all the way from Canada to Texas and from Oregon to Georgia." The hybrid seed corn industry has made phenomenal growth within a short period of 15 years.

This new agricultural practice, which took the seed corn business out of the hands of the individual farmer and placed it in the hands of commercial dealers, was not readily accepted. The value of this new practice had to be demonstrated and proved. This was ultimately accomplished by several methods. One was by extension teaching and demonstration in the corn belt states, which definitely proved that hybrids outyielded the old varieties. Also, hybrid seed companies did much by convincing large corn growers that their seed was practical. At this stage in the introduction of hybrid corn, the farmer was sometimes guaranteed that he would not have to pay for the corn unless he was satisfied that it made him a profit beyond that of open-pollinated seed. Adverse weather conditions were other factors which gave impetus to the use of hybrid corn. It was soon observed that hybrid corn had greater resistance to lodging, heat and drouth than open-pollinated varieties. Yield differences became plainly evident in 1936, which was a severe drouth year in Iowa. At this time nearly all farmers who were testing hybrid seed corn planted only a limited acreage. Yields of the hybrids under these conditions in many areas of the state were approximately double the yields of other corn grown on the farm. The results were so convincing that it marked the end of the vast efforts of initial introduction.

Greater efforts were now concentrated on developing and producing adapted hybrids for the greatly increased demand. Domination of the old open-pollinated varieties in the Iowa corn acreage was quickly reversed. In 1935 the old varieties were still grown on 95 percent of the acreage. Five years later hybrids were grown on 95 percent of the acreage and since 1942 there has been practically none other than hybrid corn grown.

The flat fields of Iowa farms lent themselves to mechanization. When hybrid corn, with its high lodging resistance, dominated the corn

¹Author of *Hybrid Corn Makers* and other popular books on agriculture.

acreage, there was a rapid increase in mechanical pickers. In 1935 only 15 percent of Iowa corn was harvested by machine, but in 1945 approximately 70 percent was harvested by machine. As two-row and four-row machinery replaced the single-row, the number of corn acres that could be tended by one man was markedly increased. By the hand methods of 1925, it took approximately 1 man hour to produce 1 bushel of corn. In 1940, with modern methods of production, the same amount of time produced approximately 13 bushels.

In the 5 years 1942 through 1946, Iowa averaged approximately 600 million bushels of corn per year. This was more than one-sixth of the total corn production of the United States and was produced on one-tenth of the nation's total acreage. If this great crop had been produced 10 years earlier when there was no hybrid corn, it would have required an extra acre for every four. In this way, hybrid corn helped in the war effort, not only in increased food production but also in saving time and manpower.

Corn is our nation's greatest farm crop. Hybrid corn with its tremendous increase in yield, has contributed immeasurably to the farmer's income and the economic welfare, security and wealth of the nation. Of equal importance is the fact that this valuable seed on a per acre basis is of relatively small cost to the farmer. Although the market price of corn has varied from \$1 to \$2 per bushel, the cost of seed per acre has remained approximately 1 bushel of corn, or about 2 percent of the gross returns.

Now, with all that hybrid corn has contributed, it should be remembered that it is something relatively new. It was less than 10 years ago that it assumed an important place in the corn acreage of Iowa. How short a time, indeed, for scientists to explore the unlimited possibilities of these new discoveries. Already it has been shown that the juggling of a gene or two can change the color of the kernel or change ordinary corn starch to that found in tapioca or to sweet corn. In reality, only a beginning has been made in greatly increasing the proteins and amino acids essential to animal and human nutrition.

No doubt this expanding knowledge in the manipulation of genetic factors in maize will give rise to greater contributions of immense value to the human race. More clearly now do we see the goal of increasing and stabilizing our food production, by making the crop still more resistant to hazards such as wind, drouth, insect pests and plant diseases. We know how to build resistance into the corn plant. Now we must develop techniques for finding and evaluating this germ plasm. Past experience with other crops has taught us not to confine our search exclusively to our own corns.

Thus it is that the Tropical Research Center has been located in Guatemala to search for genes or characters that will improve our corns and thereby contribute to greater freedom from hunger and improve the welfare and security of all nations.

In closing I would like to quote Dr. Paul C. Mangelsdorf of Harvard University, one of our nation's most outstanding authorities on hybrid corn. In his address at the Hybrid Corn Convention in Chi-

cago, Dec. 2, 1947, he said, "This one thing in this period of the world's history has probably saved more lives than any other development in applied biology, even including such important contributions as the discovery of insulin and the use of penicillin. Without question hybrid corn marks the greatest achievement in agricultural science within a matter of centuries and has enriched the world to an immeasurable degree."

La Producción Del Maíz Híbrido En Iowa

RESUMEN

POR EDWARD MAY

PRESIDENT OF THE MAY SEED COMPANY

La aplicación práctica de la ley de Méndel al maíz, comenzó en 1900, habiendo culminado, con el tiempo, en la producción del maíz híbrido, considerado como la más grande aportación a la agricultura después de la invención del arado de acero.

George H. Shull fué el primero en producir maíz híbrido, y fué él también, quien primero reconoció la importancia del mismo y sus perspectivas para el futuro. Edward M. East aportó sus conocimientos sobre los efectos de la endocría y el cruzamiento entre las plantas; pero no fué sino hasta 1917, cuando Donald Jones produjo lo que él llamó un cruce doble, que habría de aprovecharse eficazmente el vigor híbrido.

En 1922 el U. S. D. A. inició un programa de investigación sobre la materia, y ello significó que en Iowa había de llevarse a cabo un programa intenso. Sin embargo, no se pudo distribuir semilla en Iowa, sino hasta 1932, ya que la técnica de la producción no había avanzado mucho aún.

Fué muy difícil convencer a los agricultores de las ventajas que ofrecía el maíz híbrido, hasta que en 1936, año de prolongada sequía en la región de Iowa, los híbridos demostraron sus buenas cualidades como productores y resistentes. La demanda creció en proporciones considerables, y desde 1942 no se cultiva más que maíz híbrido en Iowa.

Siguió luego la mecanización del cultivo, y en 1945 más o menos un 70% del maíz cosechado en Iowa, lo fué por medio de máquinas.

Con todo, hay que recordar que el maíz híbrido es algo relativamente nuevo, y que solamente hace diez años que tuvo aceptación. Hoy día estamos al principio del trabajo que ha de conducir al mejoramiento de su riqueza alimenticia esencial para su uso como alimento del ganado.

La ampliación de nuestros conocimientos acerca de los factores genéticos, nos ofrece mayores perspectivas de provecho, y la experiencia nos ha enseñado a no limitar nuestras investigaciones a nuestras plantas solamente sino también considerar las de otros países; y con este fin, y para mútuo beneficio, ha sido establecido el Iowa State College, Guatemala Tropical Research Center en Guatemala, C. A.

Para terminar, me gustaría citar unas palabras del Dr. Paul C. Mangelsdorf de la Universidad de Harvard. "Sin duda alguna, el maíz híbrido constituye el fruto más grande de la ciencia agrícola durante varios siglos y ha enriquecido al mundo en el grado máximo."

Maize Production in El Salvador

BY ANTONIO BERRIOS MENDOZA

MINISTERIO DE AGRICULTURA Y INDUSTRIA REPUBLICA DE EL SALVADOR

El Salvador does not have trustworthy statistics on corn production. An estimate of the amount of corn produced may be calculated by using the per capita consumption for the country. The maximum known per capita consumption is 0.690 kilograms or 1½ pounds daily, but considering that the underage population and part of the adult urban population consume much less than the daily ration cited above and that corn is partially substituted for grain sorghum by the people living in the arid regions in the northern part of the country, we estimate the national consumption at about 6,160,000 quintales or about 11 million bushels. Normally corn is neither imported nor exported so that total consumption represents production.

The land area necessary to raise this amount of corn would require 238,000 hectares, or 588,200 acres, with a yield of 1,180 kilograms per hectarea or 19 bushels per acre. This would require more than 40 percent of the total arable land under cultivation in El Salvador.

THE USE OF MAIZE AS HUMAN FOOD AND FEED FOR LIVESTOCK

Practically all of the corn grown is consumed by man. When the ear is still in the milk stage, it is often eaten after boiling in salted water or roasting over an open fire. In both forms it is called elote. In this same stage the grain is eaten in the form of elotascas or riguas. Dry shelled corn is eaten as tortillas and in small amounts as atol, pupusas, pasteles and chilate. Only a small amount of corn is used as feed for pigs and poultry.

Corn represents about 70 percent of the grains (corn, beans, sorghum and rice) consumed in El Salvador.

CULTURAL METHODS

There are three methods of corn growing in the country, namely macana, wooden plow and power machinery.

THE MACANA METHOD

In recent clearings (not subject to the plow) the macana method is practiced. The land is cleared and the debris burned. Later the seed is planted, by opening the soil with a wooden stick and depositing several seeds into the hole. Weeding and hilling are done with the hoe. The yields by this method are usually low.

WOODEN PLOW METHOD

By the wooden plow method, the field is prepared as follows: The weeds are cut, piled and burned. Then the field is plowed with a wooden plow pulled by oxen. The land is plowed 4 to 6 inches deep, lengthwise and crosswise. Furrows are opened for the seed, spaced one step apart. The seed is covered with the foot. Spacings as close as 24 x 24 inches are used when no companion crop is interplanted.

POWER MACHINERY METHOD

With agricultural machinery, the land is plowed, disked and leveled before planting with tractor power machinery. The cultivation is done with oxen or tractor implements.

The common spacing is 40 inches between drilled rows and the number of cultivations varies according to needs of the land. Hilling is considered very important for weed control and support of the plants. The plant is doubled just below the ear when it is mature. Grain sorghum, pumpkins, squash and beans are the common companion crops. The first two are planted at the time of hilling and beans after doubling.

The corn is picked by hand. There are no corn harvesters in El Salvador. Removing the husks and shelling are done by hand also. Sometimes small shellers are employed to shell the corn, but power-driven shellers are seldom used.

SOME CHARACTERISTICS OF MAIZE IN EL SALVADOR

The native corns are classified vaguely according to earliness, width of ear and grain weight. The early corns are called liberal and the late are called lerdos. Cob width has particular importance because usually the corns with a small cob, known as raques, are high yielding and have large heavy kernels.

Corn is grown mainly between 30 to 500 meters (100 to 1,600 feet) altitude. At these altitudes the favorite corns are raques liberales. In Zapotitan to Sitio del Niño Valley, which is one of the main corn producing regions of El Salvador, the dent varieties Taberon and Raque Capulín are grown. The following are some of the agronomic characteristics of the two varieties:

	Variety Taberon	Variety Capulin
Grain color	white	white
Plant color	green	green, purple-red
Average height of the plant	2.61 m.	2.92 m
Average height of the ear	1.22 m	1.36 m
Number of days to silking	46	48
Average ear length	12 cm. (4.75")	11.95 cm. (4.70")
Cob color	white	white or red
Rows of kernels	14 to 16	14 to 16
Numbers of ears per plant	2	2
Percent of stand in May crop, 1947	68	72
Percent of root lodging in May crop, 1947	19.25	15.50
Yielding capacity in Sitio del Niño Valley	25-35 bu/acre	25-35 bu/acre

An examination of 170 samples of shelled corn in 1944 from several localities in the country showed the following averages:

Moisture content (Nov. and Jan.)	12.5 percent
Weight of 1,000 kernels	291 grams

NUMBER OF CROPS PER YEAR

Two crops of corn are grown per year except where irrigation is available. Where irrigation facilities or humid land is available three or four crops can be grown.

The most important crop is called *de invierno*, Shupan or May crop. The second crop is called *de verano* or *tunalmil*. This crop yields only from 50 to 70 percent as much as the May planting.

The third crop, planted in January under irrigation, is called *de apante*; on humid land it is called *de chaguite*. These last two crops are grown during the dry season. The fourth is very limited and usually is harvested when in the *elote* stage.

Time of planting experiments have shown that the best time to plant corn in Zapotitan is during the first three weeks of May. Plantings made in the middle of April are called *siembra en polvo*. The purpose for this early planting in the dry season is to permit marketing the crop early when the price is generally high. Sometimes, too, the object is to produce seed for the second and third crops. This early planting sometimes results in a poor stand, calling for replanting.

It has been observed that nitrogen is frequently deficient in some of the soils and in some cases there probably exists a phosphorus and minor element deficiency. Some farmers hold that June or late May plantings fail because of coolness of soil. Experiments have shown that the addition of nitrogen has a favorable effect on late plantings. Alfredo Martínez C. found that weeds growing with corn showed no nitrogen deficiency.

The influence on the growth of corn of such other ecological factors as rainfall, day length, temperature and relative humidity have not been studied. That they may be limiting factors can hardly be doubted.

PLAGUES THAT ARE COMMON AND DESTRUCTIVE

Among the peasants there are several erroneous beliefs about damages to corn. Some of their beliefs are founded on moon effects. Actually insects and diseases are often destructive. This is especially true on the early plantings in April and May when the rains are late, also, in September when the rainy season ends early. The *apante* or *chaguite* plantings are frequently badly injured by insects. Dry spells favor insects of corn.

There are insects which attack the growing plant and others the

TABLE 1. GROWTH AND DEVELOPMENT IN EL SALVADOR OF 36 GUATEMALAN CORN COLLECTIONS PLANTED MAY 21, 1947.

Entry No.	Collection no.	Group	Av. plant height			Av. ear height			Days to flowering	Dry weight	Yield (bushels)	Av. shelling pct.	Pct. lodged*	Pct. stalk broken*	Pct. with 3 ears
			Min.	Av.	Max.	Min.	Av.	Max.							
1	370-46	C	6' 6"	8' 6"	10' 2"	2' 4"	3' 11"	5' 7"	58	20.63	33.9	79.9	2.0	3.0	12.5
2	36-46	C	9' 6"	10' 10"	13' 2"	4' 7"	5' 10"	8' 2"	61	22.45	33.9	80.5	0.9	5.5	42.1
3	103-46	E	7' 10"	8' 10"	10' 2"	3' 11"	4' 7"	5' 3"	52	16.22	31.5	85.4	5.9	8.3	29.1
4	46-46	C	7' 10"	9' 10"	11' 2"	3' 7"	4' 10"	6' 3"	59	17.11	34.6	76.3	2.7	8.1	28.3
5	392-46	E	8' 2"	8' 10"	9' 10"	3' 7"	4' 3"	5' 7"	51	19.45	30.2	82.9	8.5	6.6	38.2
6	1A-46	M	47.5	7' 3"	8' 10"	2' 4"	3' 3"	4' 11"	80	0.0	0.0	0.0	38.5	12.2	0.0
7	39-46	M	6' 7"	9' 10"	10' 6"	3' 3"	5' 3"	6' 10"	80	0.0	0.0	0.0	62.6	14.9	2.3
8	106-46	H	62.5	9' 10"	11' 2"	5' 7"	6' 6"	7' 6"	80	0.45	1.1	52.3	33.7	17.5	17.3
9	33-46	M	8' 6"	10' 6"	11' 2"	4' 11"	6' 3"	7' 6"	80	0.0	0.0	48.3	18.1	14.7	12.0
10	101-46#	C	66.5	11' 2"	12' 9"	5' 3"	6' 3"	8' 10"	64	19.07	39.2	74.2	0.0	13.7	34.6
11	15-46	H	12' 2"	12' 9"	14' 9"	7' 3"	8' 2"	9' 10"	86	1.56	2.0	62.9	32.1	26.1	17.5
12	17-46	H	9' 10"	11' 6"	13' 5"	5' 3"	7' 3"	9' 2"	86	1.67	2.3	51.9	55.4	13.5	38.0
13	47-46	H	8' 2"	10' 6"	11' 9"	4' 11"	5' 10"	7' 3"	84	0.87	1.6	49.9	39.5	5.4	15.5
14	138-46	H	85.0				3' 3"		99	0.0	0.0	0.0	27.4	11.7	27.1
15	14-46	H	10' 6"	13' 2"	14' 9"	6' 3"	7' 10"	9' 6"	80	4.89	9.4	60.0	10.5	15.2	35.0
16	30-46#	E	7' 6"	8' 6"	9' 2"	2' 11"	3' 11"	4' 11"	52	15.01	29.7	82.9	3.6	12.0	40.3
17	13-44#	C	9' 6"	10' 2"	11' 2"	4' 11"	5' 7"	6' 3"	56	19.35	30.5	84.8	21.1	8.6	40.8
18	32-46	E	7' 6"	7' 10"	8' 6"	2' 11"	3' 7"	4' 11"	52	15.69	27.7	86.6	0.0	5.3	23.4
19	23-44#	E	6' 6"	8' 6"	9' 10"	1' 8"	3' 7"	4' 7"	56	12.21	21.1	81.3	0.0	6.3	19.3
20	42-46	C	8' 2"	11' 2"	12' 2"	5' 3"	6' 3"	6' 11"	60	18.83	31.2	78.7	7.0	10.1	19.6
21	12-46	C	10' 10"	12' 6"	14' 9"	6' 3"	7' 3"	8' 6"	64	18.68	35.0	71.9	10.2	6.8	30.7
22	7-46#	C	9' 2"	10' 2"	11' 10"	3' 7"	4' 11"	6' 11"	58	24.14	38.0	79.5	0.0	1.9	15.0
23	125-46#	C	85.0	9' 2"	10' 6"	5' 7"	5' 7"	6' 3"	56	29.26	46.6	80.7	9.7	10.6	30.3
24	9-46	C	8' 6"	10' 2"	11' 6"	3' 11"	5' 3"	6' 10"	58	27.13	43.0	74.2	1.9	4.8	38.0
25	96-46	C	77.5	9' 10"	11' 6"	4' 11"	5' 11"	7' 10"	62	18.94	33.5	81.0	6.4	5.3	39.0
26	120-46	C	90.0	10' 2"	13' 6"	5' 7"	6' 7"	7' 2"	60	20.01	30.4	78.6	0.9	6.4	32.8
27	32-46	C	82.5	9' 2"	11' 6"	4' 3"	4' 11"	5' 11"	59	28.40	47.2	82.5	9.1	3.0	27.4
28	25-46	H	67.5	7' 10"	12' 6"	4' 3"	6' 3"	8' 2"	80	1.37	20.8	77.8	29.2	19.5	27.2

Table 1. (Continued)

Entry No.	Collection no.	Group	Average stand pct.	Av. plant height			Av. ear height			Days to flowering	Dry weight	Yield (bushels)	Av. shelling pct.	Pct. lodged*	Pct. stalk broken*	Pct. with 2 ears
				Min.	Av.	Max.	Min.	Av.	Max.							
29	27-46	M	70.0	9' 2"	10' 10"	13' 2"	4' 3"	5' 11"	6' 11"	86	0.0	0.0	0.0	21.6	10.8	12.5
30	25-44X	E	57.5	5' 10"	6' 6"	6' 10"	1' 8"	2' 4"	2' 11"	49	4.80	11.3	72.4	0.0	10.0	17.3
31	104-46	E	72.5	5' 6"	8' 2"	10' 2"	3' 11"	3' 11"	4' 11"	52	15.94	29.5	83.4	17.9	7.8	57.1
32	98-46	E	77.5	7' 6"	8' 6"	9' 10"	2' 11"	4' 3"	5' 7"	50	14.69	25.7	84.9	0.0	2.1	36.3
33	134-46#	C	60.0	9' 10"	10' 2"	11' 2"	4' 11"	5' 7"	6' 11"	62	13.52	30.0	79.9	4.1	1.3	50.8
34	9-44#	C	77.5	9' 10"	10' 6"	12' 9"	5' 3"	5' 11"	7' 10"	62	14.83	26.2	75.9	7.5	8.6	38.2
55	136-46	E	82.5	8' 2"	9' 2"	9' 10"	1' 8"	3' 7"	4' 11"	56	6.09	10.2	85.0	10.2	6.1	1.4
36	50-46	H	75.0	10' 2"	10' 10"	12' 9"	4' 11"	6' 3"	7' 10"	70	5.85	10.6	74.7	5.0	5.0	25.8

sibbed seed; X selfed seed; C Coast corns; E Early corns; H Highland corns; M Mountain corns.

* Percentages calculated on basis of actual number of standing plants.

Summary of table 1. The 36 entries were planted in three randomized blocks on May 21 in the experimental grounds at San Andres. The entries comprised four groups of corn as indicated in table 1. The coast corns as a group responded best as indicated by the yields. The calculated yield trend of the 15 coast corns ranged from 26.2 to 47.2 bushels per acre; six yielded 35 bushels or more per acre or more. The early dwarf corns yielded less than the coast corns. They ranged from 10.2 to 31.5 bushels. Eight highland corns ranged in yield from 0 to 20.8 bushels, and four mountain corns each yielded zero bushels per acre. This data would indicate clearly that there probably is little use to search for high-yielding corns for El Salvador except in the coast corn group. These results are in accord with those obtained by Dr. J. E. Melhus, working in Guatemala.

stored grain. Root and stalk lodging are probably due in part at least to three different kinds of insects as yet not identified. One of these unidentified insects is a maggot that bores into the stalk of seedlings and partially destroys the growing point, either killing or stunting the plant. The plants that survive stool excessively. This disease is called empalmado in El Salvador. The maggot was isolated from diseased plants, but the reinfestation on healthy seedlings has not been attempted. Government agencies control grasshoppers and army worm infestations.

The most common insect that attacks the stored grain is the well known grain weevil. Farmers protect their seed from insects by storing it in the husk in their houses above a smoky corner where they cook. Grain in storage is protected usually with carbon-bisulfide. The main known disease is smut.

CORN IMPROVEMENT AS INTENDED IN EL SALVADOR

Eduardo Quinonez, a farmer from Suchitoto, wrote a bulletin in 1937 describing methods of selecting seed. His work considered mass selection and ear-to-the-row methods. In 1938 a French agronomist, Pierre Flandrin, started a corn improvement program at La Ceiba, but he discontinued it after the first year. Leonel Gómez of Santa Ana has kept producing a good corn on his finca La Empalizada. This corn appears to be a selection from a strain introduced into El Salvador several years ago. Lately, Rafael A. Hernández, from Comasagua, has

TABLE 2. GROWTH AND DEVELOPMENT OF SEVEN SIBBED POLLINATED CORN COLLECTIONS AND THREE TOP CROSSES FROM GUATEMALA PLANTED IN EL SALVADOR, SEPTEMBER, 1947.

Entry No.	Pedigree	Group	Total plants	Av. stand pct.	Plant height av.	Ear height av.	Av. lodging pct.	Pct. with 2 ears av.	Av. shelling pct.	Av. yield in bu.	Av. stalk broken pct.
1.	7A-46#	C	48	26.6	8' 6 "	4' 5 "	1.2	0.70	78.9	38.89	13.9
2.	9A-46#	C	42	23.3	9' 5 "	4' 8 "	2.1	0.70	51.4	31.32	4.0
3.	12A-46#	C	78	43.3	11' 2 "	5'10¼"	1.1	2.70	75.3	46.27	18.8
4.	36A-46#	C	48	26.6	9' 4½"	4' 8½"	0.0	1.33	76.0	33.34	7.5
5.	96A-46#	C	46	25.0	9' 9¼"	5' 5¼"	0.0	1.70	74.2	30.33	3.8
6.	101A-46#	C	84	46.6	10' 1½"	5' 6 "	0.0	3.33	75.8	47.09	11.3
7.	125A-46#	C	71	40.0	9' 2½"	4' 4 "	2.5	2.33	79.8	45.22	11.1
8.	9A-46x13A-46	C	66	33.3	9'11 "	4' 9½"	0.0	2.33	77.3	41.27	8.3
9.	10A-46x11A-46	C	70	38.3	10' 1¼"	5' 9¼"	0.0	1.33	81.2	46.20	16.8
10.	35A-46x308A-46	C	55	30.0	8' 8 "	4' 2¼"	0.0	1.33	75.4	41.64	8.0

Summary of table 2. Seven of the most promising corns in the spring trial in three lattices shown in table 1 were planted again in three randomized blocks as a fall crop. Three top crosses were included also. All 10 of these corns belonged to the coast corn group. The calculated yields ranged from 30.33 to 47.09 bushels per acre. Six of the entries yielded more than 40 bushels per acre. In El Salvador such a yield in a fall planted crop would be considered high. Plainly these seven Guatemalan entries need more extensive trials on a field basis as soon as seed becomes available.

been using a field cross of Capulín Ganaleno on Mexican June. By selection in the F_2 generation Hernández has obtained a good corn with long ears covered with tight husks. This corn in a yield test last year ranked second among seven other white corns and sixth among a total of 16 yellow and white corns.

A corn improvement program as yet has not been initiated in El Salvador. Its goal should be to obtain a white, medium hard, large kernel, early, two-eared, sturdy, well rooted, high yielding plant. Last year 12 varieties were crossed on one another resulting in 66 top crosses. These top crosses, as well as the parent varieties, were grown in a field trial test in 1947 at San Andrea. Each entry consisted of two rows of 10 hills each. About half of the crosses outyielded the parental varieties. They were tested again in 1948 in two localities during the rainy season, and the ones that yielded best were used as a source of material for mass selection and also for the isolation of inbred lines that ultimately may be recombined into synthetic varieties.

Along with our own program, we cooperated with the Iowa State College-Guatemala Tropical Research Center, of Antigua, Guatemala. It was thought that selected material in certain Guatemala corns might prove superior to El Salvador corns under climatic conditions similar to those in Guatemala. The Tropical Research Center provided the seed. In May, 1947 a yield test using 36 Guatemalan corns was planted in one triple lattice. The results obtained are shown in table 1.

CORN PRODUCTION NEEDS TO BE INCREASED IN EL SALVADOR

Maize is of such importance in El Salvador that its production is always a subject of public concern. Corn growing has been a non-profitable crop in El Salvador until recent years. Most of the production is in the hands of small land owners and land tenants who grow it largely as a subsistence crop. Prices fluctuate sharply with the amount produced from season to season. This is an unfortunate condition and should be corrected. Such a plan is under way in El Salvador. An increased corn production program for El Salvador calls for: (1) the storage of enough corn to permit regulation of price; (2) the practice of soil and water conservation methods along with the use of chemical fertilizers, green manures and crop rotations; (3) better seed; (4) the establishment of agricultural machinery centers and personnel prepared to fit the land for the small farmer at cost; (5) provisions to reclaim coastal lands suited to corn production and (6) promotion of a program of converting corn through animal feeding into such high concentrates as beef, pork, mutton, milk, cheese, butter, eggs, lard, etc., of much more value than straight corn.

La Producción Del Maíz En El Salvador

RESUMEN

POR ANTONIO BERRIOS MENDOZA

MINISTERIO DE AGRICULTURA E INDUSTRIA REPUBLICA DE EL SALVADOR

La producción total de maíz en El Salvador puede estimarse en 6,160,000 quintales. Se considera que para producir tal cantidad de maíz se necesitan 238,000 Has. con un rendimiento de 1,180 Kgs. por Ha.

Prácticamente todo el maíz producido en El Salvador es consumido por el hombre en forma de alimento, en estado de "elote," y en tortillas, tamales, Pupusas, atole, etc. En efecto el maíz constituye el 70% de todos los granos consumidos en el país (frijol, maíz, arroz).

El maíz se cultiva por los métodos siguientes: Macana, arado de madera y maquinaria motorizada.

El maíz salvadoreño es clasificado vagamente en temprano o "Liberal" y tardío o "Lerdo"; habiéndose observado generalmente que los maíces con olote delgado son los mejores productores.

Se exponen los caracteres agronómicos de las variedades "Taberón" y "Raque Capulín."

En el curso de varios experimentos se ha llegado a la conclusión de que el mejor tiempo para sembrar parcelas experimentales de maíz, es el comprendido en las tres primeras semanas de Mayo. Las plantaciones tardías tanto como las muy tempranas fracasan generalmente; en algunos lugares sin embargo se pueden sembrar hasta cuatro cosechas al año.

Los daños causados por los insectos son considerables, especialmente durante intervalos de sequía y se observan generalmente en la planta y en el grano; para proteger el maíz del gorgojo, es práctica común tratarlo con humo o bien con bisulfuro de carbono. La enfermedad fungosa mas común es el Carbón del maíz. .

El mejoramiento del maíz en El Salvador ha ocurrido solamente en pequeña escala y por iniciativa individual de los finqueros. La meta de un programa para el mejoramiento del maíz en El Salvador sería obtener un maíz blanco, de consistencia media, grano grande, temprano, de dos mazorcas, fuerte, con sistema radicular vigoroso y buen rendimiento. Se han hecho 66 cruces intervarietales con 12 variedades, con estas miras. También se llevó a cabo una prueba de rendimiento, con varios maíces guatemaltecos, proporcionados por The Tropical Research Center en Antigua, Guatemala, de acuerdo con nuestro programa de cooperación.

El cultivo del maíz se lleva a cabo comúnmente por los pequeños agricultores, quienes lo cultivan para proveer a sus necesidades. Los precios fluctúan cada estación, de acuerdo con la producción.

Un programa para el aumento de la producción de maíz en El Salvador comprendería los siguientes puntos:

- (1) El almacenamiento de suficientes reservas de maíz para regular los precios.

- (2) El empleo de métodos científicos para la conservación de los suelos (fertilización, etc.).
- (3) La producción y uso de mejor semilla.
- (4) El establecimiento de centros de maquinaria agrícola al servicio del pequeño agricultor, a precio de costo.
- (5) El uso de las tierras de la costa apropiadas para el cultivo.
- (6) La promoción del uso del maíz para la alimentación del ganado.

Methods Used and Results Obtained in Corn Improvement in Mexico

BY E. J. WELLHAUSEN AND L. M. ROBERTS

GENETICIST AND ASSOCIATE GENETICIST, ROCKEFELLER FOUNDATION

In Mexico corn is grown under a wide range of conditions. It is grown at sea level in narrow strips along the Gulf and Pacific coasts. Inland it is cultivated in numerous mountain valleys ranging up to 2,800 meters in elevation. In the coastal areas and up to about 1,400 meters, corn can be grown 12 months a year if moisture is available. Average temperatures are high. At 1,400 to 2,000 meters temperatures occasionally drop a few degrees below freezing in November, December or January. At higher elevations killing frosts can be expected any time from September to April. Above 2,000 meters, night temperatures often drop below 50°F. during the frost-free growing season.

Rainfall varies from more than 3 meters in some of the tropical areas to about 100 millimeters in certain places on the high plateau. On the high plateau the rainy season normally starts in May or June and ends in October. Corn varieties maturing in 3½ to 4½ months are most popular. Later maturing varieties are sometimes grown under irrigation.

The various isolated mountain valleys with different climatic conditions have been very conducive to the development of a great number of different types and varieties of corn. Varieties have been found which vary in maturity from 3 to 8 months. The latest maturing varieties have been encountered in the State of Chiapas. Plants of different varieties range in height from 5 to 20 feet and ears vary from 3 inches in the earliest corns to 15 inches and over in some of the later types. In number of rows per ear, varieties range from 8 to 26.

COLLECTION, IDENTIFICATION AND TESTING OF EXISTING VARIETIES

The first step in the corn improvement program of Mexico was the collection and testing of existing types, in order to (1) identify superior varieties for immediate distribution to farmers, (2) furnish foundation material for subsequent improvement and (3) conserve existing germ plasm for future uses.

To date approximately 1,800 samples have been collected, representing a range from the most primitive types to the most recent agricultural types being used for commercial corn production. The most primitive types have largely been replaced by more productive types in the various areas and are rather hard to find.

Tests of all collections have been limited to the most important corn growing areas, for it is in these areas that an improvement in yield capacity will have its most immediate effects in reducing the corn deficit in Mexico. The four most important corn growing areas are as follows: (1) the Mesa Central, with elevations from 2,000 to 2,400 meters, in the States of Mexico, Michoacán, Hidalgo and Puebla; (2) the Bajío, with elevations from 1,200 to 1,800 meters in the States of Jalisco, Guanajuato and parts of Michoacán and Querétaro; (3) northern Bajío, including northern Guanajuato, northern Jalisco, Aguascalientes and parts of Querétaro; and (4) tropical areas represented chiefly by the State of Veracruz.

The results obtained from tests in the first two areas have been published (9).¹ The data set forth in this publication show that the adapted varieties native to the same general area vary greatly in their capacity to yield within the same maturity class. For example, in the Bajío, the very early, adapted varieties varied from 1,500 to 3,164 kilos per hectare; the early, adapted varieties varied in yield from 1,710 to 3,484 kilos per hectare; late varieties from 1,603 to 3,549, and very late varieties from 769 to 3,078. A similar range of variation may be found in the Mesa Central or in the tropical zone. Varieties not native to the four important corn growing areas were usually found to be unadapted and very poor in yield.

These early studies made with open-pollinated varieties definitely indicate that within any given area with similar climatic and soil conditions certain superior varieties exist in a limited scale, which if distributed over the entire area to replace all inferior ones would result in considerable improvement in the total amount of corn produced.

The superior open-pollinated varieties which have so far been selected

TABLE 1. SUPERIOR OPEN-POLLINATED VARIETIES, THEIR ESTIMATED INCREASE IN YIELD OVER THE AVERAGE OF ALL ADAPTED VARIETIES TESTED AND AMOUNT OF SEED DISTRIBUTED.

Area	Variety	Estimated increase in yield over average of all varieties	Amount of seed distributed in 1948
Northern Bajío	Rocamex V-216	25	54,900 K.
	Rocamex V-221	25	30,775 K.
Mesa Central	Rocamex V-7	26	204,525 K.
	Rocamex V-21	15	24,450 K.

¹Numbers in parenthesis refer to literature cited in the bibliography.

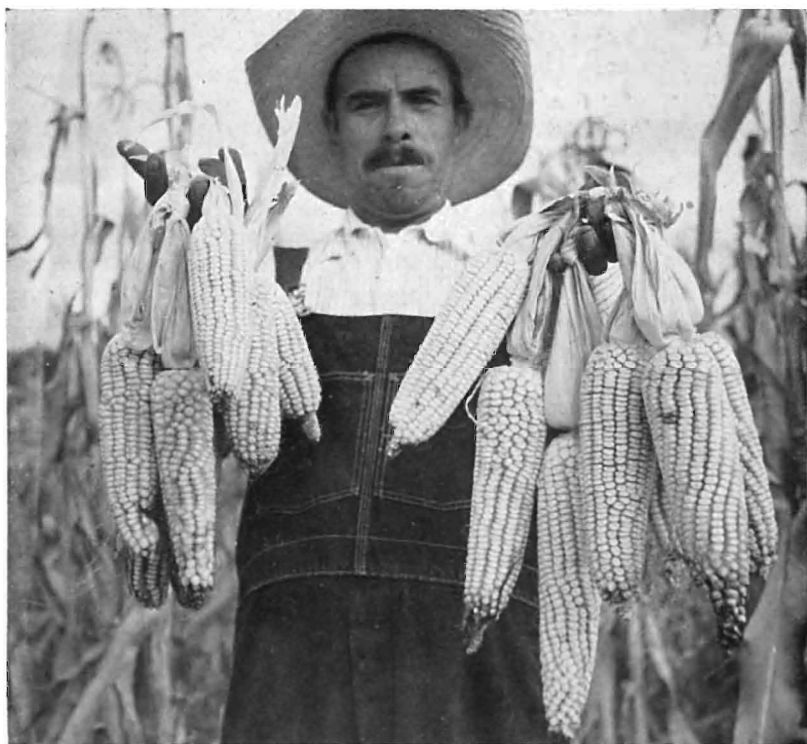


Fig. 1. Varieties improved through breeding have given substantial increases in yield over the old standard varieties. The farmer above is exhibiting ears from the improved variety (right) in comparison to those of the old variety grown under the same conditions.

for large scale increase and distribution in the respective areas are given in table 1.

IMPROVEMENT THROUGH BREEDING

In Mexico an improved variety which can be propagated by open pollination by individual farmers on their farms has tremendous advantages. Very few farmers in the early stages of a corn improvement program can be persuaded to adopt the practice of planting hybrid corn and obtaining new seed each year. Also in a country where hybrid corn has never before been produced, large scale production and distribution of seed is practically impossible without first developing an organization of trained personnel. It seemed, therefore, that, under the circumstances existing in Mexico, the immediate logical step in the further improvement of varieties was through the development of synthetics that could be propagated by open pollination. The number of generations a synthetic variety may be maintained without a substantial decrease in yield has not been determined. The majority of the farmers

in Mexico select their seed very carefully with respect to uniform ear and grain type, and with such intensive selection for type, yields no doubt will decline.

IMPORTANT TECHNICAL CONSIDERATIONS IN THE PRODUCTION OF SYNTHETICS

Before presenting some of the results obtained with synthetic varieties, it seems wise to examine some of the theoretical aspects involved. As Sprague and Jenkins (8) pointed out, four factors operate to determine the yield of advanced generations of hybrids: (1) the number of lines involved, (2) the mean yield of these lines, (3) the mean yield of all of their possible single crosses and (4) the percentage of self-pollination.

Which of the above factors is the most important is rather difficult to say. Since maize is almost wholly cross pollinated, the last factor may be largely ignored. Apparently in the past it was thought that a large number of lines was of primary importance, for all the early experiments with synthetics involved eight or more lines: Hayes (1) 8 and 17; Kiesselbach (3) 8 and 16; Sprague and Jenkins (8) 16 and 24.

Wright (10) has shown that with random mating the vigor and productiveness of an F_2 is less than that of the F_1 by an amount equal to $1/n$ th of the difference between the F_1 and the average of the parental lines where "n" is the number of parental lines involved. For example, if two inbred lines each yielding 60 percent of an open-pollinated variety when crossed yield 120 percent, the F_2 should decline below the F_1 by $1/n$ th or $1/2$ of the difference between 120 and 60 percent, which is 30. The yield of F_2 therefore is 90 percent of the open-pollinated variety. However, if four inbred lines are involved with the same yielding ability (60 percent) the decline would be $1/4$ of the difference or 15 percent, resulting in a calculated yield of 105 percent for the F_2 .

These theoretical conclusions of Wright concerning the reduction between F_1 and F_2 are adequately supported by experimental data from maize. Neal (7) compared the yield in F_1 and F_2 of 10 single crosses, 4 three-way crosses and 2 double crosses. The average decrease was 29.5, 23.4 and 15.8 percent while the theoretical reduction in yield should have been 31.1, 21.0 and 15.2 percent, respectively.

The loss of vigor (difference in productiveness between F_1 and P_1) should be 50, 33.3 and 25 percent for single crosses, three-way crosses and double crosses, respectively. Decreases actually found in Neal's experiments were 47.6, 36.8 and 25.8 percent, respectively.

Kiesselbach (4) compared the F_1 , F_2 and F_3 of 21 single crosses with the parental inbred lines. The average yield of inbreds was 24 bushels. The average yield of the F_1 , F_2 and F_3 was 57.0, 36.4 and 37.8 bushels, respectively. The theoretical yield of F_2 and F_3 should have been 40.5 bushels. This is not greatly different from the results actually obtained.

According to the Pearson-Hardy law, random bred populations reach genetic equilibrium in the F_2 . Therefore one would not expect further reduction in succeeding generations in the absence of selection.

Apparently in the past in estimating the number of lines to use in a synthetic, it was assumed that the F_1 mean in Wright's formula could be taken as a constant value regardless of the number of lines involved. Therefore the more lines involved the higher would be the yield of the resulting synthetic. In actual practice, however, synthetics with a large number of lines have yielded little more than the open-pollinated varieties. As indicated by Kinman and Sprague (5), the assumption of a constant mean yield for all F_1 combinations seems unwarranted. In any series of inbred lines there are some that combine better than others. It is much easier to obtain four inbred lines that yield well in all possible combinations than 10 or 16. The mean yield of all possible single crosses will be higher for four or five good combiners than when a larger number of lines are involved, many of which rank lower in general combining ability. Therefore, to bring about highest mean yield of all possible single crosses, the use of relatively few lines is indicated.

Furthermore, it can be shown that a better synthetic might be made with four more productive lines than with eight less productive. For example, assuming the mean yield of all single crosses involved to be 120 percent, an F_2 of a synthetic involving four lines with a mean yield of 80 percent will yield 110 percent, while a synthetic involving eight lines yielding only 30 percent will yield 108 percent in F_2 .

Kinman and Sprague (5) in their studies conclude that in general the most efficient number of lines to be included in a synthetic will vary with the range in combining ability among the inbreds available as parents. On the basis of their study four to six lines appear to be the most efficient number, the smaller number being most efficient when more productive lines (yielding at least 75 percent of open-pollinated variety) were involved.

Theoretical consideration, therefore, points to the use of four to six lines as productive as possible which are good combiners when crossed inter se.

The easiest way to obtain higher yielding lines is through reduction in the amount of inbreeding. Generally, homozygous lines will yield from 25 to 45 percent of the open-pollinated variety from which they were obtained while good first generation selfs will yield up to 75 or 80 percent. Jenkins (2) has shown that in combining ability; first generation selfs are not greatly different from lines selfed six to eight generations. All evidence points to the use of first generation selfs as the best procedure in the production of synthetics.

In the formation of synthetics certain practical aspects must also be taken into consideration. For example, the greatest amount of hybrid vigor is generally obtained by crossing unrelated lines. However, if the inbred lines that are combined are greatly different, the resulting F_2 may be extremely variable in both type of ear and maturity. This is a serious objection for many farmers who have become used to the

more uniform highly selected old varieties. Some kind of selection for uniformity may be necessary and with it yield may drop.

More uniform synthetics may be obtained by using related inbreds, but related inbreds in combination usually give lower yields than unrelated. The problem is to select first generation inbred lines high in combining ability without introducing too much variability.

SYNTHETICS PRODUCED AND RESULTS OBTAINED

The problem in Mexico was to improve the best open-pollinated varieties in the shortest possible time and get them into large scale production immediately. In consideration of all the theoretical and practical angles, it was decided that the most rapid improvement of any one variety would be through the production of double top-cross synthetics. In the production of double top-cross synthetics fewer good lines are needed. Also if the open-pollinated variety chosen for the top-cross parent is a good yielder and well adapted to the area in which improvement is attempted, the synthetics made with it are also very likely to be well adapted making long-time testing unnecessary. In making up the double top crosses, procedures were as follows:

1. A variety known as Urquiza well adapted as an early variety in an area varying from 1,800 to 2,200 meters in elevation on the high plateau was chosen as the parent with which all lines were to be crossed.
2. Approximately 200 selected first generation lines representing a wide range of types were crossed with Urquiza.
3. The top crosses were tested at different elevations between 1,800 and 2,200 meters.
4. Outstanding top crosses involving various unrelated lines were chosen for making double top crosses. Each top cross selected was crossed only with every other top cross that contained a line unrelated to it.
5. Ninety double crosses were made and tested in the area to which they were adapted.
6. From these 90, six were selected for increase and distribution.

The results obtained are best illustrated in table 2.

The inbred lines used were first generation selfs of three types, namely, Celaya (C), León I (LI) and Tabloncillo (Tab.). Of these three types León I was similar to Urquiza. The other two were quite

TABLE 2. YIELDS OF TOP CROSSES AND DOUBLE TOP CROSSES IN PERCENT OF THE OPEN-POLLINATED VARIETY (URQUIZA).

Double top cross	Yield of top crosses		Av. yield of two top crosses	Av. yield of double top crosses
	(a)	(b)		
(C 2622 x Urq.) x (LI 149 x Urq.)	171	135	153	150
(LI 24 x Urq.) x (Tab. 566 x Urq.)	115	155	135	142
(LI 162 x Urq.) x (Tab. 566 x Urq.)	129	155	142	140
(LI 162 x Urq.) x (Tab. 783 x Urq.)	129	125	127	135
(LI 56 x Urq.) x (Tab. 566 x Urq.)	126	155	141	143
(LI 24 x Urq.) x (Tab. 395 x Urq.)	115	158	137	143
Urquiza	100	100	100	100

distinct and unrelated. The Celaya lines in general when top-crossed on Urquiza gave the highest yields but were too late for general use in the area in which the synthetics were to be used. The León I and Tabloncillo lines were earlier than the variety on which they were top-crossed. Earliness (115-120 days) was one of the characters desired in the synthetics.

In general the early top crosses involving lines from Tabloncillo were much higher in yield than those containing lines from León I. This might be expected on the basis of relationship. Tabloncillo is a long, narrow-eared, eight-rowed corn with short, wide, thick grains, of distinct origin, whereas León I is a variety of the conico type, with fairly short ears, high row number, and long narrow grains similar to Urquiza in origin.

The F_1 yield of the double top crosses (average of three locations) ranged from 135 to 150 in percent of Urquiza. The yield of the double top crosses was not greatly different from the average of the two top crosses combined. This indicates that little or no additional increase in hybrid vigor was obtained by bringing together the inbred lines in the double top cross.

The question that remains to be answered is how much of the gain in yield in F_1 can be maintained in F_2 .

Mangelsdorf (6) has indicated that the yield of advanced generations of double or multiple top crosses may be computed from the following formula:

$$\text{Yield of } F_2 = \frac{n^2a + 2n^2b + (n^2 - n)c + nd}{4n^2}$$

a = Yield of open-pollinated variety

b = Average yield of all top-cross combinations

c = Average yield of all single-cross combinations

d = Average yield of inbred lines

n = Number of inbred lines

Not all information is available to calculate yield of the F_2 but an estimate of the yield might be obtained by assuming certain values for those that are lacking. For example, the value of the various components of the formula for the first double top cross may be taken on a percentage basis as follows: a = 100; b = 150; c = 150; d = 75; and n = 2.

On this basis the calculated yield of the F_2 is 128 percent which is a little more than half of that gained in F_1 over the open-pollinated variety Urquiza, or in other words, about 44 to 46 percent of the difference between F_1 and Urquiza may be expected to be lost in F_2 . Accordingly the advanced generations of the synthetics listed in table 2 theoretically should retain a yield of from 19 to 28 percent more than the open-pollinated variety set out to improve.

In an experiment conducted in 1947, involving 31 individual comparisons between F_1 and F_2 generations of double top crosses, the loss

in excess vigor (difference between F_1 and P_1) was considerably below the theoretical loss as calculated from the formula. The actual yield of the variety Urquiza, the mean yield of F_1 double top crosses, mean yield of the F_2 generation of the same top crosses and the calculated yields are given below:

	Kilos per hectare	Pct. of Urqui. ^a
Yield of variety Urquiza	3,982	100
Mean yield of F_1 's	5,267	132
Mean yield of F_2 's	5,022	126
Calculated yield of F_2	4,599	116

According to the data the advanced generations actually held 81 percent of the yield gained in F_1 compared to 50 percent as calculated.

The amount of seed produced of the various synthetics (double top crosses) and where adapted, are shown in table 3.

The synthetics VS 201 to VS 227 are very similar. All were increased in order to get maximum increase of improved seed for a specific area. VS 320 and VS 322 are somewhat later in maturity. Of those listed only three will be continued: namely, VS 101, VS 203 and VS 320.

The percentage of the acreage replaced in the various zones by the improved seed is rather difficult to determine. The point is that enough of it has been distributed to arouse the interest of the farmer and to have some effect on actual production. Demands for seed continued long after all of it had been distributed.

These releases represent the first experience with synthetics in Mexico. One of the chief objections commonly expressed with respect to these synthetics was that they were too variable. The first generation inbred lines from a very different type known as Tabloncillo used in the formation of these synthetics were largely responsible for the increased yields, but also introduced considerable variability in ear type. This lack of uniformity presents an imagined obstacle to farmers who are used to growing a highly selected uniform type.

TABLE 3. AMOUNT OF SEED DISTRIBUTED IN 1948 OF THE FIRST SYNTHETICS PRODUCED.

Name of synthetic	Kilos of seed* distributed 1948	Zone adapted
VS 101	45,300	Mesa Central
VS 201	67,800	Northern Bajío
VS 203	198,522	Northern Bajío
VS 207	101,875	Northern Bajío
VS 219	103,025	Northern Bajío
VS 227	165,739	Northern Bajío
VS 320	286,200	Northern Bajío
VS 322	96,956	Northern Bajío

*Figures obtained from the Comisión del Maíz in charge of seed distribution.

USE OF HYBRIDS

The theory involved in the production of hybrid corn of the type grown in the United States is well known and needs no further discussion. The advantage of a hybrid over a synthetic is that hybrid vigor may be utilized at its maximum. However, if hybrid corn is to be successfully produced in Mexico, it must be produced simply and at low cost to the farmer especially in the early stages of the program.

Although the majority of the farmers are not ready for the utilization of hybrid corn, there are certain ones that can and will make use of it for commercial corn production if seed is made available at a reasonable cost.

In order to discourage the growing of hybrids in an area in which they are unadapted, hybrids for each of three different areas, Mesa Central, Bajío and Northern Bajío, were developed simultaneously.

Approximately 2,000 hectares were planted in 1948 for the commercial production of hybrid seed to be distributed in 1949. The number and kinds of hybrids put in production varied with the locality.

In the Mesa Central corn is planted in March and April under irrigation and the first part of June when the rains come. Thus at least two different varieties are needed. The early planting date provides a 5 to 5½ month growing season, whereas the second allows only about 4 months. For the early plantings the selected variety V-7 has been outstanding, but hybrids made with first generation lines have proved to be quite superior. The yield of two hybrids compared with the open-pollinated variety V-7 is given in table 4.

TABLE 4. YIELD OF HYBRIDS FOR MARCH PLANTINGS IN THE MESA CENTRAL COMPARED TO THE OPEN-POLLINATED VARIETY V-7.

Variety	Pedigree	Yield kgs./ha.	Yield in pct. of V-7
Hybrid	(Urq. 54 x Hgo. 3-5) x M 37-5	6213	127
Hybrid	Hgo. Comp. 1 x Urq. Comp. 1	5677	116
V-7	Selection from O.P. Variety	4902	100

The first hybrid is a three-way cross of which M 37-5 is a first generation inbred line sufficiently vigorous to be used as a pollinator. It yields more than the selected variety V-7 by 27 percent and will be put in production in 1949. The second hybrid is an example of what might be obtained by pooling lines. Four first generation lines from a variety known as Hidalgo that combined well with Urquiza in top crosses were pooled into a synthetic. Likewise four first generation Urquiza lines were pooled to form a synthetic, but their combining ability with the Hidalgo variety was not known. These two synthetics were then crossed; the resulting F₁ hybrid outyielded V-7 by 16 percent. This hybrid is of interest because the parents may be propagated as open-pollinated varieties eliminating the necessity of first forming single crosses and the maintenance of four inbred lines as is the case in a double cross. It is possible that this hybrid might be further

TABLE 5. YIELDS OF THE THREE-WAY CROSS H-120 COMPARED TO THE SELECTED OPEN-POLLINATED VARIETY V-21 AND THE SYNTHETIC VS-101.

Variety or hybrid no.	Pedigree	Yield in kgs./ha.	Pct. of V-21
Hybrid H-120	(Urq. 54 x Pue. 6-1) x Mich. 21-20	3748	133
Synthetic VS-101	(Mich. 21-5 x Urq.) x (LI 24 x Urq.) F ₃	3217	114
Selected var.	V-21	2818	100

improved by inbreeding synthetic Hgo. Comp. 1 and testing the combining ability of the first generation lines with synthetic Urq. Comp. 1 and vice versa inbreeding Urq. Comp. 1 and testing the lines with Hgo. Comp. 1. The best combiners from each synthetic could be recombined into new synthetics which when crossed might result in a higher yielding F₁.

For planting at the beginning of the rainy season in the Mesa Central the open-pollinated variety V-21 and synthetic VS 101 are well adapted. However, a three-way cross (H 120) involving first generation inbred lines has been found to be superior. About 20 hectares were planted for seed production in 1948. The results obtained with this hybrid on the basis of 1 year's test, in comparison to the open-pollinated variety V-21 and synthetic VS 101 released for distribution in the Mesa Central last year, are given in table 5.

For the Northern Bajío area a double cross hybrid H-215, also made up of first generation selfed lines, has been released for commercial hybrid seed production. In table 6 the yields of this hybrid are compared to the yield of synthetic VS-320, one of the better synthetics adapted to the same area.

This is an early hybrid that seems very promising and is widely adapted in the Northern Bajío area (1,800-2,000 meters). Approximately 100 hectares were planted in 1948 for seed production.

The area known as the Bajío varies mainly between 1,400 and 1,800 meters in elevation although certain areas drop down to 1,200 meters above sea level. It is a very important corn area with several good open-pollinated varieties. Within this area the wide distribution of a variety known as Celaya (widely grown around Celaya, Guanajuato) is being promoted by the Experimental Station of the Mexican Department of Agriculture at León, Guanajuato. It is a productive variety found to be widely adapted in the Bajío region.

As an attempt to improve this variety, several double top crosses were made up involving inbred lines out of the Celaya type and two open-pollinated varieties, one of which was Celaya (Gto. 59A) and the other was a variety containing considerable Tabloncillo germ plasm designated as Jal. 35. First generation inbred lines farthest removed

TABLE 6. YIELD OF HYBRID H-215 IN COMPARISON TO SYNTHETIC VS-320.

Variety	Pedigree	Yield kgs./ha.	Yield in pct. of VS-320
Hybrid H-215	(LI 24 x LV 126-2) x (Urq. 66 x Qro. VI-101)	3248	141
Synthetic VS-320	Advanced generation of double top cross	2297	100

in relationship from Celaya were top-crossed on Gto. 59A, whereas first generation lines from the Celaya type were top-crossed on Jal. 35.

These top crosses were tested for yield and desirable agronomic characters. The most outstanding top crosses with Gto. 59A were combined with the most outstanding ones with Jal. 35 to make double top crosses. Comparison of the best of these double top crosses with Celaya in yield is shown in table 7.

TABLE 7. YIELDS OF DOUBLE TOP CROSSES ADAPTED TO THE BAJIO COMPARED TO THE OPEN-POLLINATED VARIETY CELAYA.

Hybrid	Pedigree	Yield kgs./ha.	Yield in pct. of Celaya
H-305	(Mich. 30-60 x Gto. 59A) x (L-II-123 x Jal. 35)	4845	120
H-301	(L-II-123 x Gto. 59A) x (Mich. 30-33 x Jal. 35)	4411	108
Celaya	Open-pollinated variety	4092	100

The double top cross hybrid H-305 yielded about 20 percent more than Celaya and was equal in maturity. Hybrid H-301 yielded only 8 percent more than Celaya but was about 10 days earlier which is a decided advantage in years with limited rainfall. The major portion of the 2,000 hectares planted in 1948 for hybrid seed production was planted to these two double top-cross hybrids.

The best three-way and double crosses made up of first and second generation inbred lines yielded somewhat higher than the double top crosses. The results are given in table 8.

TABLE 8. YIELD OF THREE-WAY AND DOUBLE CROSSES COMPARED TO CELAYA.

Hybrid	Pedigree	Yield kgs./ha.	Yield in pct. of Celaya
3003	(M 30-60.3 x L-II-243-2-2) x (G.61-5-4 x Ag. 172-2)	5359	133
3019	(L-II-90 x Ag. 172) x (L-II-123 x L-II-243)	5279	129
H-307	(L-II-67 x L-II-90) x Ag. 172	5084	125
Celaya	Open-pollinated variety	4092	100

The highest yielding hybrid in table 8 (No. 3003) is a double cross made up of lines with two generations of selfing. However; it has only a slight advantage over No. 3019 which was made with first generation lines. Further tests are needed to show whether or not the difference is significant. Hybrid No. 3019 would have a definite advantage over 3003 as a synthetic in advance generations because the inbred lines are higher yielding. In 3019 it is estimated that the inbred lines will yield about 75 percent of Celaya whereas those in 3003 will probably not average more than 50 percent.

In the early stages of the hybrid program it will be extremely difficult to convince farmers that much is to be gained by planting F_1 seed of a double cross every year. Farmers are so accustomed to planting their own corn seed from year to year that it is almost certain that a majority of them will plant advanced generation seed the first few years. It is very important that the hybrids distributed also make good synthetics. Number 3019 has all indications of making a good syn-



Fig. 2. The principal use of corn in Mexico is for human nutrition in the form of tortillas. Present production is not sufficient to supply the needs of the people. Production can be greatly increased through the extensive use of improved varieties and better cultural methods.

thetic. Each of the six possible F_1 crosses between the four lines yielded about the same, around 129 percent of Celaya. All lines are about the same maturity, similar in vigor and come from the same type of corn. The resulting synthetic can be expected to be at least as uniform as Celaya. According to Wright's formula it should maintain a yield of 15 percent above Celaya which is the best of the local varieties grown in the Bajío.

CONCLUSIONS

It is evident that the methods used in the improvement of corn in Mexico during the 4 or 5 years that the program has been under way have given excellent results. The tests of existing varieties indicated that certain varieties in the same general area are much superior to others. These alone, if distributed on a large scale within their area of adaptation, may eventually replace the inferior types and result in a substantial increase. Selections from such varieties have been increased and distributed. Furthermore, it may be concluded from the results obtained that double top crosses offer a means of rapid improvement over the best native varieties. In the formation of the double top crosses, one needs to be cautious in the use of widely unre-

lated material, for such crosses result in extreme variation to which farmers in general object.

In making up synthetic varieties, first generation selfed lines should be used. It has also been shown that excellent double cross hybrids can be made from first generation selfed lines. These same double crosses in advance generation may make good synthetics which means that those farmers who are unwilling to plant newly crossed seed every year may still have a 15 percent advantage in yield over the varieties which they formerly grew.

Hybrids made from crosses of two synthetics, each consisting of a pooled set of closely related lines that combine well with a different pooled set of closely related lines, offer considerable promise in the production of low cost seed. The maintenance of lines for hybrid production is greatly simplified in this way.

Although the yield results presented here are based only on 1 or 2 years' tests, they nevertheless indicate what can be done. The use of first generation lines has a twofold advantage: (1) high yielding synthetics or hybrids may be formed in a shorter time; (2) first generation selfs are more easily propagated under adverse conditions than advanced lines. The disadvantage in the use of first generation lines is that the contaminants or outcrosses are more difficult to spot, and a line may become modified in a few generations.

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Métodos Usados Y Resultados Obtenidos En El Programa De Mejoramiento De Maíz

RESUMEN

POR E. J. WELLHAUSEN AND L. M. ROBERTS

GENETICIST AND ASSOCIATE GENETICIST, ROCKEFELLER FOUNDATION

Los métodos usados y resultados obtenidos en el programa de mejoramiento de maíz en México durante los últimos 4 o 5 años en que dicho programa ha estado realizándose, han sido presentados. El primer paso fué coleccionar aquellas variedades que se desarrollan bajo condiciones similares y probarlas en ensayos comparativos. Como un resultado directo de este trabajo, quedó demostrado que ciertas variedades sembradas en escala limitada y para un área específica son muy superiores a otras. Un incremento substancial e inmediato en rendimiento podría ser obtenido, substituyendo todas las variedades inferiores por una superior ya en existencia. Aproximadamente 315 toneladas de semilla fueron distribuidas en 1948 de 4 variedades de polinización libre, seleccionadas, las cuales rindieron de 15 a 25% más que el promedio de todas las variedades comunmente sembradas en las mismas áreas.

Un mayor mejoramiento de las mejores variedades nativas de polinización libre, fué ganado a través de la formación de variedades sintéticas. Los aspectos teóricos y prácticos en la formación de variedades sintéticas han sido discutidos.

Se han presentado datos demostrando que ciertos mestizos dobles (sintéticas) rindieron alrededor de 20% más que las mejores variedades de polinización libre. Las líneas que entraron en la formación de las variedades sintéticas fueron de primera auto-fecundación.

El tercer paso en el programa de mejoramiento de maíz ha estado constituido por la formación de cruces triples y dobles, usando líneas con sólo una generación de auto-fecundación. Ganancias substanciales en rendimiento sobre las variedades sintéticas han sido logradas. Se ha concluido que los cruces dobles en los cuales han intervenido líneas con una auto-fecundación (A_1) pueden llenar un doble propósito. Un cruce doble puede ser hecho de tal manera que sea también un buen sintético en generaciones avanzadas de este cruce doble. Lo anterior significa que aquellos agricultores que no usen la nueva semilla, producto de la cruz hecha cada año, todavía tienen un margen de ventaja en rendimiento sobre las variedades que ellos primeramente han usado.

Se presentan datos sobre una variedad de maíz híbrido con base en el cruce de dos variedades sintéticas; cada una de las cuales consiste en un grupo de líneas muy semejantes o relacionadas entre sí, que se combinan bien con otro grupo de líneas en las mismas condiciones de semejanza y relación. Este método parece promisor en cuanto a la producción de semilla a bajo costo. El mantenimiento de las líneas para la producción de híbridos es grandemente simplificado de esta

manera. El uso de líneas con una generación de auto-fecundación en las primeras etapas del mejoramiento, ha sido amplia y fuertemente abogado y como resultado de ello, se concluye que presenta una doble ventaja: (1) Sintéticos e híbridos de alto rendimiento pueden ser formados en un corto tiempo. (2) Las líneas son más fácilmente propagadas bajo condiciones adversas.

A Summary of Some of the Maize Researches in Guatemala¹

By I. E. MELHUS, J. R. WALLIN AND GEORGE SEMENIUK²
IOWA STATE COLLEGE-GUATEMALA TROPICAL RESEARCH CENTER

The study of maize in Guatemala was initiated in 1944 with a preliminary reconnaissance comprising most of Guatemala and some of the other countries in Central America and parts of Mexico. This continued into 1945 when it became clearly evident that the only way to know the corns of the region was to grow them under different climatic conditions and follow their development over a period of years. The impressions gained in 1944 and 1945 were that very great diversity and variability existed in maize in the tropics. In general it was like the corns of the United States, but in many respects, very different. The extreme variations in vegetative and reproductive characters were confusing. Still further, the variations within small fields were baffling and not subject to consistent interpretation. The impact of the variables within a given field sharply modified the vegetative and reproductive characters. The variables in a given field were in fertility, erosion, moisture, exposure, spacing, plants per hill, replanting, and insect and disease injury. Often the climate was different in fields less than 500 feet apart, brought about by altitude, exposure, rainfall, light intensity and temperature. (See fig. 1.) Corn is grown under much wider climatic conditions in Central America than in all of the United States. To rely on the measurement of characters as they occurred in the fields in different sections of the country led only to conflicting conclusions.

There was left one alternative and that was to grow the different corn collections and follow their development from the seedling to maturity. Our first efforts were in the direction of establishing plots in different sites extending from Guatemala to Mexico, Arizona and Texas, Colorado and the low corn belt section of central Iowa. The range involved

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Fig. 1. A typical stretch of highland terrain, used in part for corn production. Such terrain provides wide variations in climate and soil conditions that are directly reflected in the growth and development of the corn plant.

about 29 degrees latitude and differences in altitude of nearly 8,000 feet. The data accumulated on growth response all pointed clearly in one direction. The vegetative stage was vigorous and long and the reproductive stage short and underdeveloped. The response was not that

observed in the fields of Guatemala. Plainly, transplanting the corns into widely different latitude climates was not the best way to segregate the inherited characters from responses induced by climatic changes, or to screen out characters that might enhance United States corns.

In 1946 six sites in different climates were selected in Guatemala, all within one degree latitude with differences of 8,000 feet. These sites were Antigua (4,953 feet), Tiquisate (150 feet), Chocola (2,700 feet), Barcena (4,858 feet) near Guatemala City, Coban (4,200 feet), and Labor Ovalle (8,133 feet) near Quezaltenango. In 1947 only five sites were used; Chocola was omitted. The rainfall ranged from 23 inches in Antigua to 120 inches in Coban. An attempt was made to study the growth response of the same corns at all sites.

The results of these studies for the past 2 years have been a great aid to a clearer understanding of the Guatemalan corns. As might be expected, the corns of a given climatic region respond best when grown in that region, but the fact that a corn was collected in a given region or climate did not necessarily mean that it was indigenous to that region. For example, a collection made in a mountainous region might be a coast corn or a highland corn. This difference cannot be easily detected at a given time by observation and measurement alone, but by moving this corn to another altitude the differences become apparent. The Indígenas of Guatemala carry their corn from place to place and they frequently travel more than 100 miles to work and to sell their goods. Still further, it is a common practice to sell their crop immediately after it is harvested, because they have no storage facilities to preserve it from insect destruction. Thus, not long after the crop is harvested, the Indígena has to buy corn for his family. He purchases in the market and the corns in the market may or may not be local corns. When planting time comes, the Indígena plants what he can buy, and in purchasing corn the chief criterion is quality. Is it dry, hard and bright? He may ask whether it is early or long season, but the price and the quality determine what corn he buys. (See fig. 2.) Many Indígenas try to save their seed by storing it in the loft, over that portion of their one-room houses where the cooking is done. The smoke tends to prevent some insect destruction. However, when there is no money to buy corn, the corn saved for seed goes for tortillas. All of this explains why many corns are out of place from the standpoint of the group to which they belong. Of course, the influence of these out-of-place corns leads to hybridization and mixtures with variations almost without end. The valleys and regions having a single variety often mentioned in the literature by early explorers probably do not exist. Only when these corns are brought into the most favorable climate do the inherent characters become most clearly defined. Uniform trials in the different climatic zones afford a means of detecting mixtures, and distinguishing inherent variations from those incident to climate responses. This method of segregating variations is not new. It has been used in studying other species of flowering plants, fungi



Fig. 2. Corn is retailed in the markets and small stores. In the market the producer sells corn when his crop is in season and buys for tortillas and seed when the home supply is exhausted. This practice promotes mixtures and variations in the corns throughout the whole country.

and bacteria. The only thing that may be new is the application to corn and the interpretation.

Maybe a few specific examples taken from actual observations and measurements of vegetative and reproductive characters may serve to illustrate the statements made above, i.e., when the mountain corns (those grown at an altitude of 6,500 to 10,000 feet, in a mountain temperate climate) were grown on Finca Alotenango, near Tiquisate (150 feet altitude) in a tropical climate, the development of the vegetative stage was quite normal but the reproductive stage was sup-

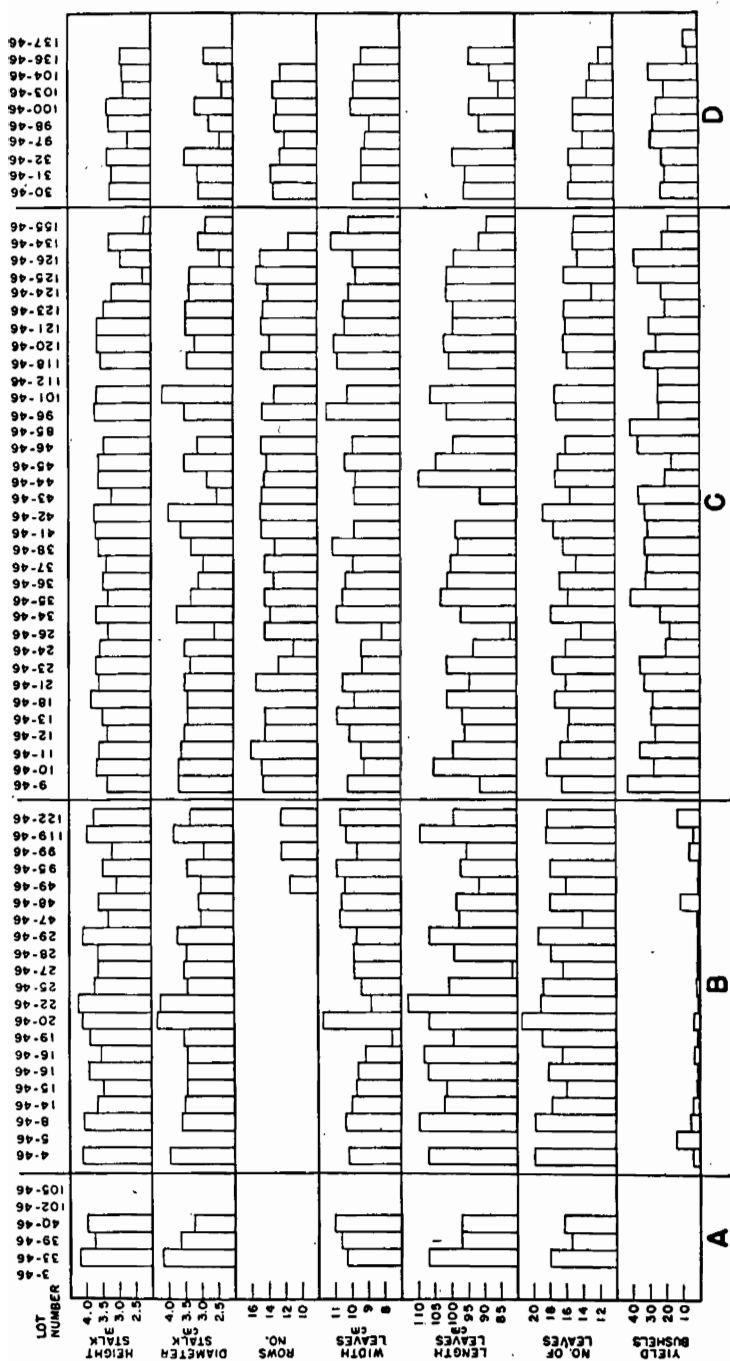


Fig. 3. The development of seven characters of 71 lots of Guatemalan corns grown at Tiquisate (150 feet altitude). The different corns are arranged into groups. A = mountain, B = highland, C = coast and D = early dwarf. Tiquisate is located in a low coastal climate.

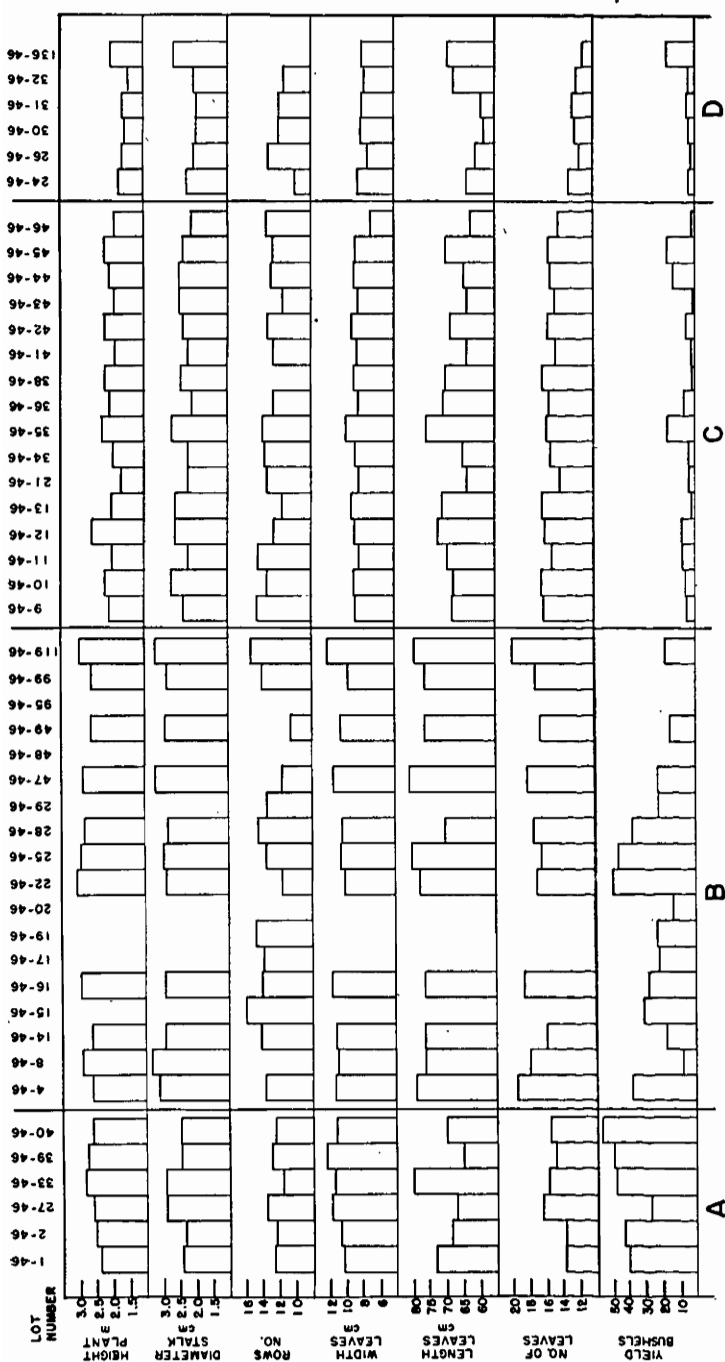


Fig. 4. The development of seven characters of 46 Guatemalan corns grown at Quetzaltenango (8,133 feet altitude) in 1946. The groups are: A = mountain, B = highland, C = coast and D = early dwarf. Quetzaltenango is situated in a mountainous temperate climate.

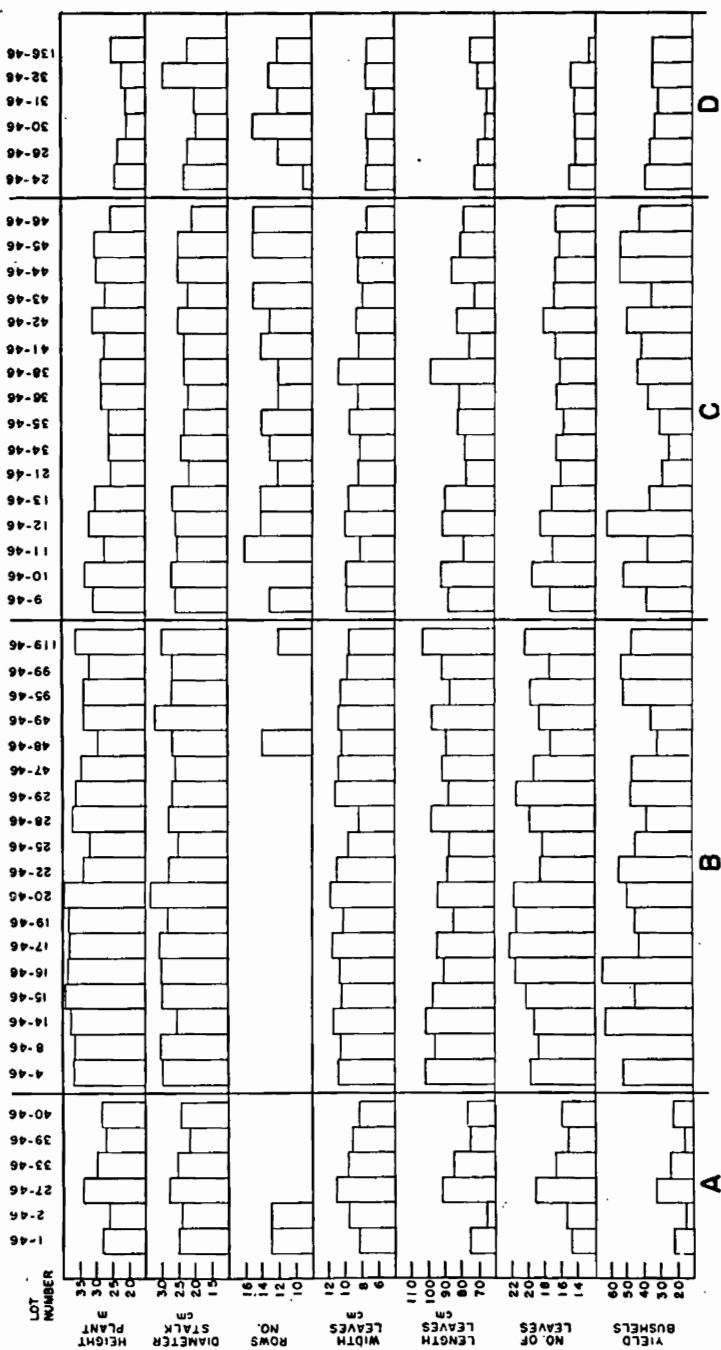


Fig. 5. The development of seven characters of 46 corn collections grown at Barcena (4,853 feet altitude) in 1946. The groups are: A = early dwarf, B = coast, C = highland, D = mountain. Barcena is located in a highland climate.

pressed. The yields at the low altitude tropical climate were often very low, while in the mountain temperate climate they were from 10 to 40 bushels per acre. The vegetative stage was influenced less than the reproductive, but always to some extent in certain characters, as lodging, root development, etc. The coast corns in the same replicated plot presented an entirely different picture. (See C in Fig. 3.) However, when the coast corns were planted in the mountain temperate climate, they were dwarfed and definitely segregated as a group. (See C in fig. 4.) The response of the highland corns (4,000 to 7,000 feet) and the early dwarf corns (1,000 to 6,000 feet) showed the same trends in growth response as the mountain and coastal corns, but the reactions were intermediate between the two extremes manifested in the mountain and coast corns. Figure 5 shows the response obtained when these corns were grown at Barcena at 4,858 feet altitude. Here the highland corns developed well as manifested in the leaf number, height and yield. In the other three groups the reproductive stage was impaired. The same type of mixture occurred in the highland, coast and early dwarf corns, as was described above for the mountain corns. Thus a grouping based on the region or climate in which a corn occurs was misleading. A better grouping was possible by using measurements of 21 characters of the vegetative and reproductive stages of the different corns coupled with the response in four to six different climates. Seven characters of the 21 are shown in figs. 3, 4 and 5.

The corns studied have been arranged in four groups based on vegetative and reproductive characters and climate response in different climates. These groups may prove to be, finally, ecotypes, races, varieties or subspecies. No claim is made that this grouping applies other than in Guatemala. In our studies this grouping proved convenient and useful in searching for characters and qualities that may aid in classification and have value when imparted to existing varieties and hybrids. As our studies continue, using more collections and inbred material of each collection as well as corns from regions outside of Guatemala, a more refined classification may be possible. An attempt has been made to describe the different groups using some of the gross characters and their climatic response. It is expected, as further detailed knowledge of the corns in hand becomes available, that changes in the grouping and descriptions may be necessary.

GROUPS OF GUATEMALAN CORNS

MOUNTAIN CORNS

Characteristics of mountain corns include: culms generally 2 to 3½ meters, diameter 2 to 4 centimeters; 12 to 18 functional drooping leaves at flowering, 7 to 16 centimeters wide, 60 to 120 centimeters long; leaf sheaths mostly purple or sun-red, and tomentose; tassel branches 5 to 25, mostly purple; ear shoots upright, single, branched or multiple; husk rough, purple to green, tight at tip; large-budded tapering ears; kernel rows 8 to 16, regular or irregular; kernels white, yellow,

purple or mixed colors, mostly flinty, some soft starchy; strongly rooted, brace roots common; long season, maturity 6 to 10 months. (See fig. 6.) Ear shoots developed poorly in the lowlands. There were many variants. Some strains grew more rapidly in the early stages of development than other corns. The yields of this class in general were inferior to the highland corns, and it was more sensitive to climate change, especially low altitude climates, than the other groups of corn. (See figs. 6, 7 and 8.)

EARLY DWARF CORNS

Early dwarf corns have: culms $1\frac{1}{2}$ to $2\frac{1}{2}$ meters, $1\frac{1}{2}$ to $2\frac{1}{2}$ centimeters diameter; 8 to 16 functional leaves at flowering, 6 to 12 centimeters wide, 50 to 90 centimeters long, leaf sheaths green and smooth; tassel branches 8 to 24; ear shoots upright, shanks short, husks rough and tightly sealed at tip of ear; ear small, tapering, 8 to 16 rows, semi-dent, semi-flint to flinty kernels, shallow, white or colored; cob large, red or white; strong root system, few brace roots. Inasmuch as they need only a short season, 3 to 4 months, early dwarf corns are grown as a quick crop from 1,000 to 6,000 feet. They are also grown

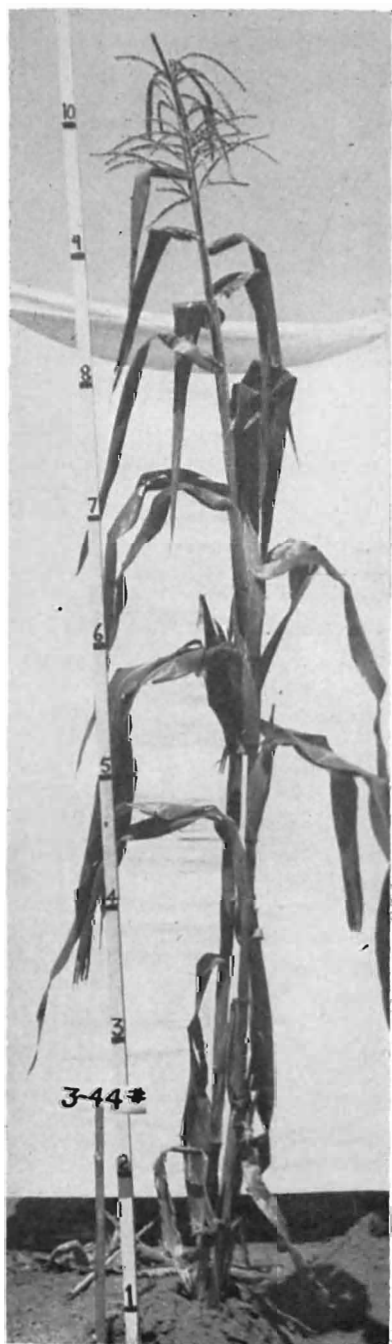


Fig. 6. This mountain corn was collected at Quetzaltenango in 1944. It was from the 1943 corn grown at 7,800 feet altitude. The mountain corns are distinguished from the other corns of Guatemala by their plant characters and habit of growth. The stalks are slender, 2 to 4 centimeters in diameter with 12 to 18 dark green functional leaves, often lopped downward. The ear shoot shanks are short, ears erect, husks purple. The ears are short with big butts and shallow flinty kernels in straight or irregular runs.



Fig. 7. (Left) An ear of mountain corn showing the large butt and pointed tip. The kernels are broad and irregular at the butt end, shallow and markedly flinty at the tip end. The size varies sharply in the mountain corns. Often in the corns grown at 8,500 to 9,000 feet the ears are short, 4 to 6 inches, with a big cob and shallow flinty kernels.

Fig. 8. (Right) A common characteristic of the mountain corn is the purple color of the leaf sheaths, tassels, husks of the ears and also the tomentose condition of the leaf sheaths and margin of the leaves.

in dry regions as a first and second crop the same season. There are many strains and variations in earliness, size, endosperm characters, tassel branches and ear shoots. The number of leaves, size and earliness of these corns distinguish them from the other groups. As a whole, the yielding capacity was the lowest of the four groups. Three different early dwarf plants are shown in fig. 9.

HIGHLAND CORNS

Highland corn characteristics are: culms $3\frac{1}{2}$ to 6 meters, diameter 2 to 5 centimeters; 18 to 24 functional leaves at flowering, 8 to 15 centimeters wide, 60 to 120 centimeters long; leaf sheaths green, sun-red or purple, smooth to lightly tomentose; 8 to 50 tassel branches; green, reddish or purple; ear shoots upright, single, branched or multiple; husks rough and tightly sealed at tip; ears with big butts, tapering, 8 to 24 rows; kernels white, yellow, purple or mixed, shallow, wide semi-flint to flinty; strong root system and brace roots often well developed. Many variants occur in the same field in ear shoot, tassel, leaf and culm characters. These are very large corns grown extensively in the highlands of Guatemala at 4,000 to 7,000 feet, re-

quiring 5 to 6 months to mature. These corns have proved, as far as tested, to be the highest yielding corns in Guatemala. Under especially favorable conditions some strains of these corns may be 8 meters tall, suggesting the group name *giganteum*. Figure 10 shows the vegetative stage of three different highland corns, 12½ to 14 feet tall, with 20 to 22 leaves. The ear characters are shown in fig. 11.

COAST CORNS

Characteristics of coast corns include: culms 2 to 3½ meters, 2 to 4 centimeters diameter; 12 to 18 functional leaves at flowering, 7 to 12 centimeters wide, 80 to 100 centimeters long, leaf sheaths green, smooth; tassel branches 10 to 30; ear shoots upright, single, branched or multiple; husks rough and tightly sealed at tip; ears pointed, rows 10 to 18 yellow-white, mixed, mostly semi-dent, some flint; strong roots, many brace roots in many strains; adapted to coastal and lowlands, sea level to 4,000 feet; 3 to 4 months to maturity. The most common characteristic of these corns was their wide distribution in the coastal and lowlands of Guatemala. This is a very heterogeneous group with some well defined strains. In yield, this group ranks second to the highland corns and has a wider climatic range than the other three groups. The vegetative characters of three coast corns 8 to 10 feet tall,

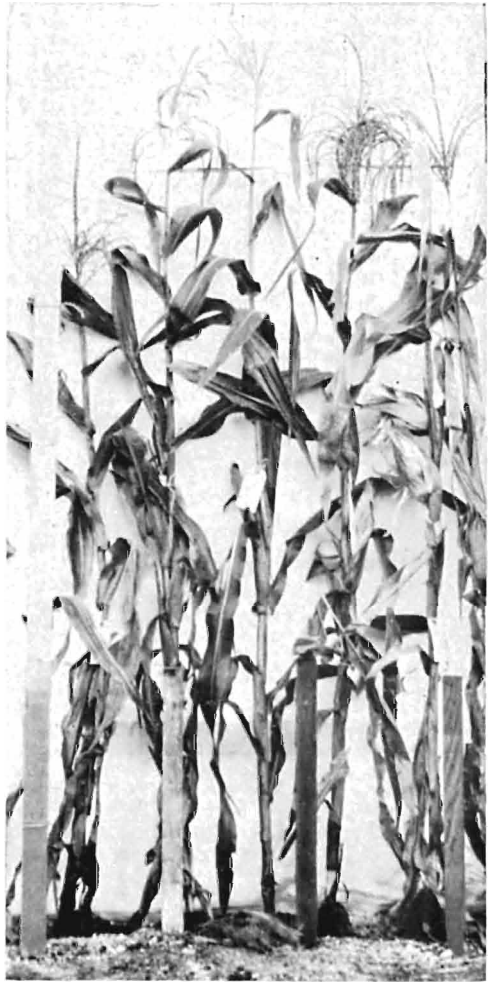


Fig. 9. The early dwarf corns carry a low functional leaf number, 10 to 14; short stalks, 6 to 8 feet tall; low, short shanked ears; and smooth, green leaf sheath. The early dwarf corns are short seasoned, low yielding corns. This is a variable group.

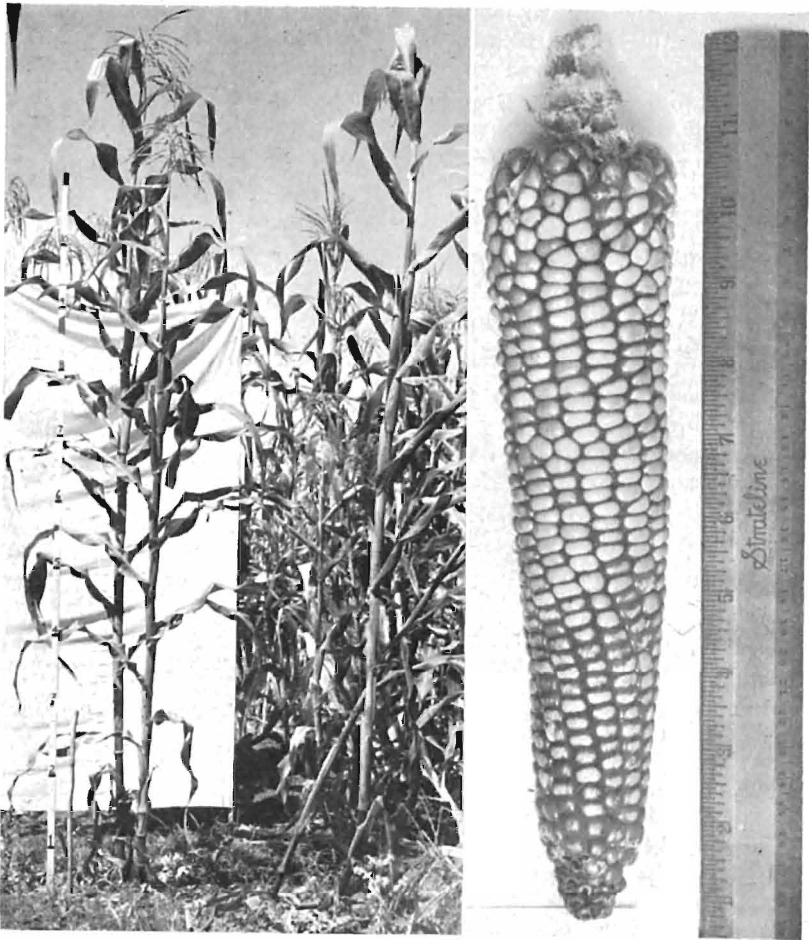


Fig. 10. (Left) The highland corns are large, late, long seasoned corns. They have 20 to 26 leaves, thick stalks, many brace roots, no suckers, long pointed ears on short, sometimes branched, ear shanks. This is the Nanne variety grown in Antigua in 1948. The highland corns may be considered as the giganteum group.

Fig. 11. (Right) An ear of a highland collection showing the ear characters—the ears are long with big butts, have short strong ear shanks, kernel rows irregular at the butt and short, wide, semident to shallow, flinty kernels at the pointed end of the ear.

with 14 to 16 leaves, are shown in fig. 12, and the ear characters in fig. 13.

A SEARCH FOR OUTSTANDING CHARACTERISTICS AND QUALITIES

Incident to the studies of the different maize collections, the corns were evaluated for insect and disease resistance, yield, cold, drouth and heat reaction and hybrid combining qualities.

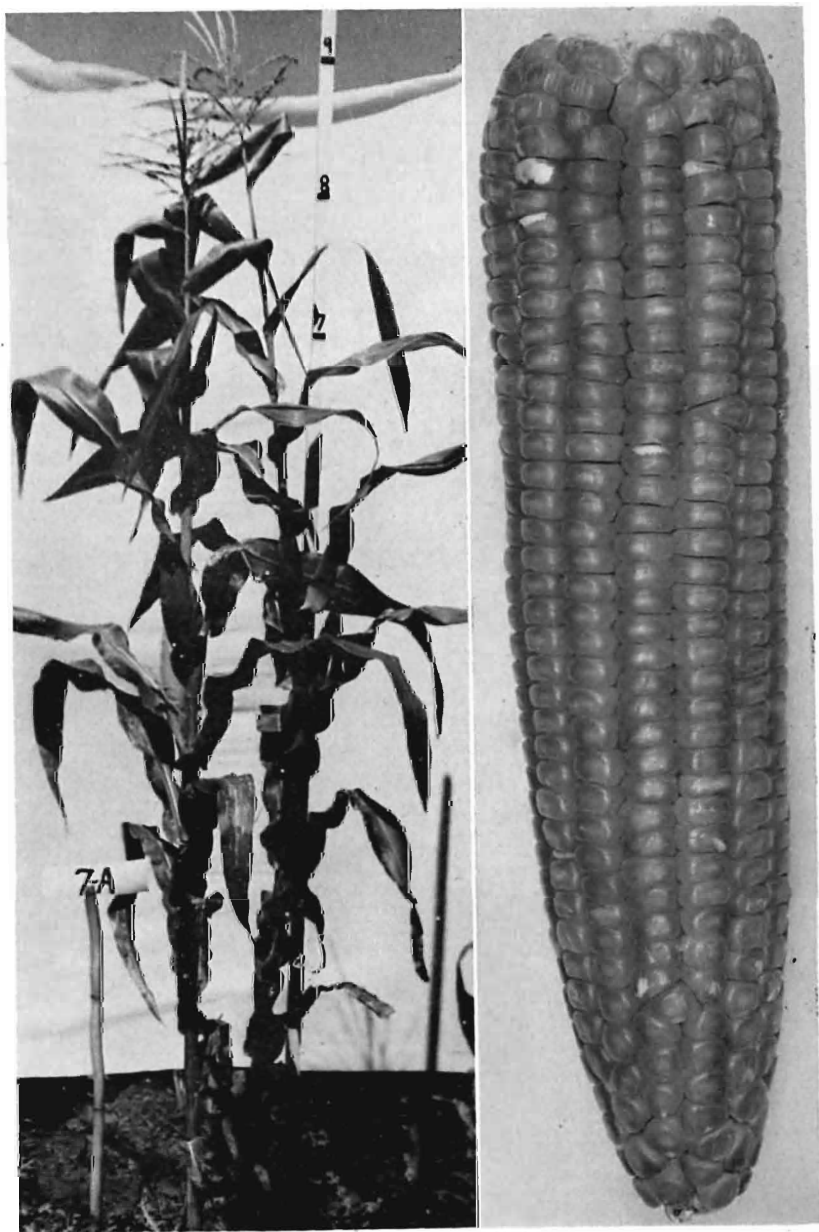


Fig. 12. (Left) A coastal corn grown at Antigua in 1946. The vegetative stage was normal—height 8 to 10 feet, leaf number 14 to 18, green smooth leaf sheaths, ear short, 6 to 10 inches, with mostly flinty kernels. This group of corns is more like U.S. corns than the corns in the other three groups.

Fig 13. (Right) This is the ear of a coastal corn, 7A-46, a reselected strain. The ears are short, 5 to 8 inches, and have pointed straight rows of golden yellow, flinty corn. The size, row number and maturity are typical of coast corns.



Fig. 14. A row of 7A-46 planted in five replications with 45 other Guatemalan collections in 1946 on Tiquisate land heavily infested with wireworms. Only four of the collections had any plants that survived the root injury. Two of the four surviving collections had only a few plants in the five replications. Collection 7A-46 and a collection from which 7A-46 was selected showed a high survival. Definitely 7A-46 was resistant to wireworm injury.

A WIREWORM-RESISTANT CORN

Wireworms often cause serious corn root injury which is different from rootworm damage so common in the highlands of Guatemala. The resistance to wireworm attack in 7A-46, does not mean that this corn carries resistance to the corn rootworms. Fifty-two corn collections were planted in five replicated 20-hill blocks at Tiquisate in the spring of 1946 on a piece of abandoned banana land grown to weeds the previous season. The soil in this plantation carried a high population of wireworms and the root injury was severe. In fact, all of the collections except four, and two of these with only a few surviving plants, were killed before the plants came into flower. (See fig. 14.) The other two collections were 7A-46 and 35A-46. The former was superior to the latter. The collection 7A-46 originated from a single ear selected from 35A-46. Collection 35A-46 was selected in ear from the progeny of two Cuban varieties grown together in a small plot at Tiquisate, Guatemala, by Enrique García Salas. It is probable that these corns were originally carried from Guatemala to Cuba, and later to other countries in Central and South America. Number 7A-46 proved to be wireworm resistant and yielded between 40 and 45 bushels per acre of good quality corn in our experimental plots for the past two crops. The kernels were flinty and fairly deep golden yellow. It is an early coast corn that matures in 110 to 120 days. The characters of the plant and ears are shown in figs. 12 and 13. Its chief faults were small ears, 6 to 8 inches, and short ear shanks. About 20,000 pounds of this corn was distributed in 1949 by Guatemalan government agencies.

A *HELMINTHOSPORIUM TURCICUM* LEAF BLIGHT RESISTANT CORN

Helminthosporium leaf blight is a very serious disease in the Coban area. It causes a loss of from 2 to 50 percent of the crop depending on how early in the development of the crop the foliage is attacked. In the Coban trial plots in 1946, involving 45 collections, largely the same corns as those grown at Tiquisate, one collection as it developed, remained remarkably free from Helminthosporium leaf blight, a characteristic quite absent in all the other 44 collections. The accession number of this collection was 47A-46. In 1947, three other maize collections were found to be resistant to this same leaf blight.

Number 47A-46 was grown in an increase plot in Coban and in an ear-to-the-row plot in Barcena in 1947. Its vegetative characters are shown in fig. 15. In both sites only a small amount of leaf blight developed. Many other collections near these two plots had 25 to 50 percent of the foliage destroyed. This Helminthosporium leaf blight collection is a variable highland corn with long slender ears. (See fig. 16.) Under favorable conditions the ears are 12 to 15 inches long and tapering, with mostly 10 to 14 rows of small, flinty, light yellow, flat kernels. In 1946, it was one of the top 27 in 75 entries in a yield test at Barcena, yielding more than 40 bushels per acre.

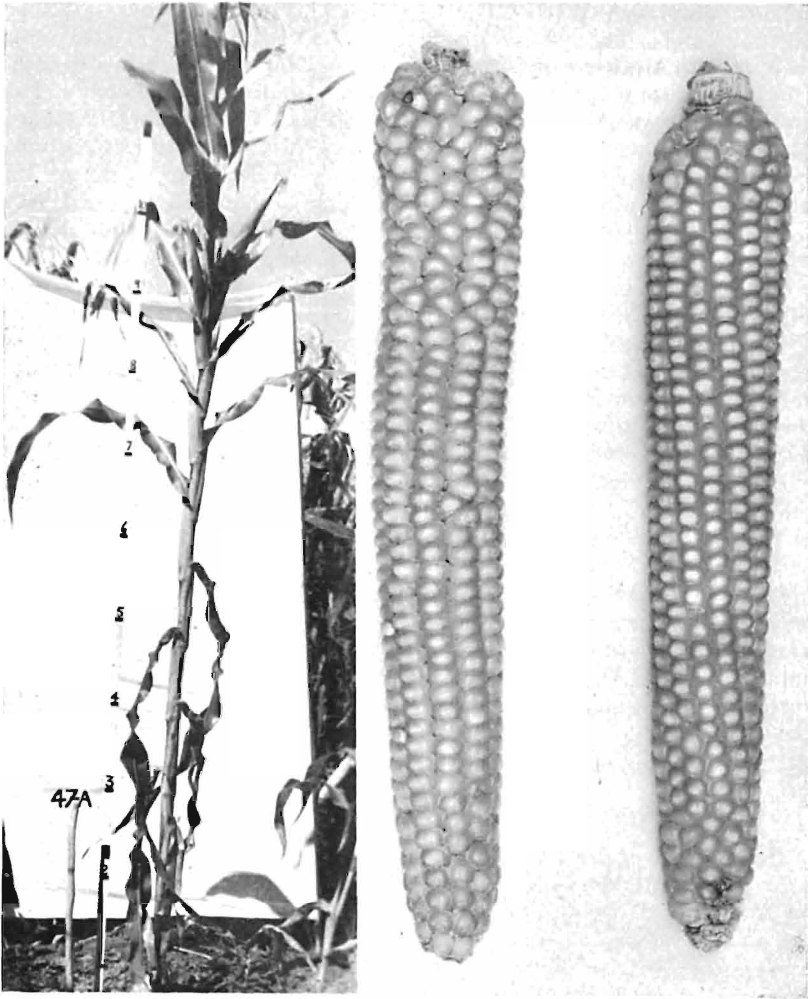


Fig. 15. (Left) This plant is a highland corn that has shown consistently strong resistance to *Helminthosporium* leaf blight in field trials in three different climates in Guatemala. The ears are long, 8 to 15 inches, slender and pointed with shallow, flinty, short, rounded kernels. This corn was collected in the Coban area where leaf blight is often destructive to the corn crop.

Fig. 16. (Right) Two ears of a *Helminthosporium* leaf blight resistant corn, 47A-46, collected in Coban. It is a highland corn with long pointed ears and short flinty kernels. This corn proved resistant in trials in 1946 and 1947.

THE NANNE CORN

The Nanne corn is said to have originated from a cross between a Wisconsin yellow corn and a Guatemalan corn grown by the late Enrique Nanne near Guatemala City. There are many strains of the Nanne variety. They vary in leaf number, maturity and kernel shape and color. In most cases the ears are long, 8 to 12 inches, with large butts and

soft to flinty, shallow kernels. At present this corn is widely grown in the highlands. The past few years it has been distributed as seed through the Ministry of Agriculture to other parts of Guatemala. In trials at Barcena in 1946 this corn was one of 27, in 75 entries, that yielded more than 40 bushels per acre.

MOVING GUATEMALAN CORN GERM PLASM IN HYBRID COMBINATION INTO THE CORN BELT

The preliminary survey of 1944 showed that there were in Guatemala many corns that differed sharply from those grown in the corn belt. The question immediately arose, how can these corns be studied in the climate of the corn belt. In 1945 an attempt was made to transplant these Guatemalan corns into different altitude and latitude climates in the United States, but the results were discouraging. Their growth and development in these northern climates was radically different from that in Guatemala. Very few of the many collections grown flowered and produced viable seed. In most cases they were killed by frost early in the reproductive stage.

This led to exploring the possibility of moving Guatemalan germ plasm into the corn belt in hybrid combination. The practicability of such a procedure was unknown. For example, it was not known how readily these giganteum highland corns would combine with U.S. inbreds, and if they did cross freely what characters of the Guatemalan and U.S. inbreds were retained or lost in the hybrid. Too, would the top crosses, three-way crosses or backcrosses mature with U.S. corns when grown in Iowa? These and many other questions needed to be answered before the desirable characters of certain strains of Guatemalan corns could be moved into the corn belt.

THE RESPONSE OF TOP CROSSES (U.S. INBREDS X GUATEMALAN CORNS) IN GUATEMALA AND IOWA

The first hybridizing was done in the Rio Grande Valley of Texas in the spring of 1945 using 12 U.S. inbreds in most cases as ear parents. The Guatemalan corns were mostly open-pollinated highland and mountain corns. These were chosen because of their vegetative vigor and sharp differences from our U.S. corns. In the spring of 1946, small 10-hill plots were planted at Antigua, Guatemala, and at Shenandoah, Iowa, in order that the influence of the Guatemalan parent on the vegetative and reproductive development of the hybrids might be observed.

The 88 top crosses and 16 male parents were planted on irrigated land on May 20, in Antigua. The earliest hybrids were shedding pollen 59 days after planting. Most of the hybrids flowered 2 to 4 weeks earlier than the open-pollinated male parents. The hybrids were shorter with fewer leaves and had more uniform ear shoot production and height in time of flowering than the Guatemalan male parents. The ear

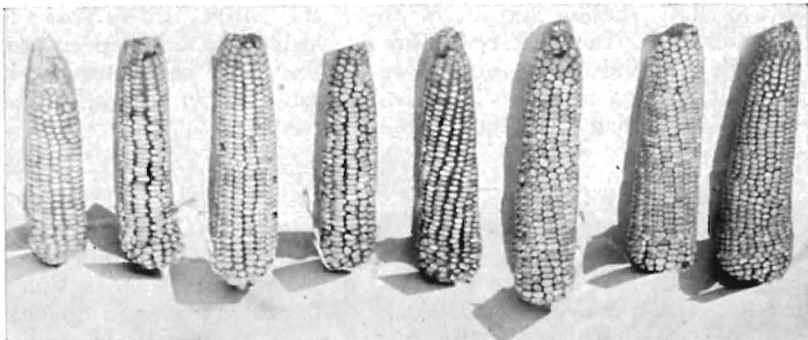


Fig. 17. The ears of eight different top crosses (U.S. inbreds \times Guatemalan) grown in Antigua in 1946. The vegetative and ear characters were strongly enhanced by the ear parents. The hybrids were earlier maturing than the Guatemalan corns, and the ear size in many of the hybrids was larger and of better quality than the Guatemalan pollen parents.

parent characters were more apparent in the hybrids than those of the male. This was strikingly apparent in the ear characters, as to size, shape and kernel characters. The ears were more uniformly cylindrical with dented kernels rather than tapering and flinty as in the male. (See fig. 17.) Some of the crosses showed considerable sterility and others excessive multiple ear development. The yield trend of the top crosses was superior to that of the Guatemalan pollen parents.

In the Shenandoah, Iowa, trials there were 56 hybrids, together with the U.S. inbred ear parents, and the Guatemalan males. It was particularly gratifying that the hybrids having highland male parents matured before frost. The leaf number was intermediate. The hybrids had 16 to 22 with an average of 18 functional leaves.³ The corn belt commercial hybrids had 14 to 18 leaves and five of the United States inbreds had 11 to 17 with an average of 13. Ten of the Guatemalan parents had from 20.4 to 24.6 with an average of 22 leaves. The influence of the U.S. inbreds was very apparent in the height, leaf number, root development, ear shape and character of kernels. The conical ears of the male parent were absent in the hybrid. The tight rough husks, two or more ear shoots and shank of the male parents were present in some of the hybrids. The lodging resistance of the hybrids was superior to all other corns in the plots. Although no attempt was made to measure yield of the hybrids, the size and number of ears per plant indicated that the yield was good. The quality of the grain was good. The data seemed to indicate that late highland corn germ plasm in top crosses would mature and produce abundant seed.

³The functional leaf numbers as used in this summary refer to the number of leaves above the crown at time of flowering. It is not the total number of leaves of the plant from seedling to full vegetative development. Functional leaf counts were made in the field and indicated differences in plant development. Node counts would be a more accurate index of plant response, but could not be made without sacrificing the plant, which was impractical.



Fig. 18. This is a topcross (L317 crossed on a highland Guatemalan open-pollinated corn, No. 1437-45) growing at Ames, on Sept. 25, 1947. The ears were large, 8 to 10 inches long, with a moisture content of 27 percent at harvest on Oct. 14.



Fig. 19. A U.S. commercial hybrid, U.S. 13. The ruler was 6 feet long. Note the corn was short and injured by the hot dry summer weather. Under favorable conditions it is a large vigorous hybrid, but only 15 percent of the leaf area was green on Sept. 25. The ears were 8 to 10 inches long, had an average weight of .51 pounds and moisture percentage of 20.7 at harvest on Oct. 14, 1947, at Ames.



Fig 20. These four plants were pulled in experimental trial plots in Ames on Sept. 25, 1947. The root systems of the two U.S. commercial hybrids were less extensive than those of the backcross 420x(61dx420) and the top cross, 194-44xL289. The larger root systems may have accounted for their greater drouth and heat tolerance in July and August in 1947.

THE GROWTH AND DEVELOPMENT OF THREE-WAY, BACK-CROSSES AND TOP CROSSES AT AMES, IOWA, IN 1947

The work in 1946 had shown that it was possible to bring Guatemala highland corn germ plasm up to Iowa in top-cross hybrids that would produce good quality seed of a somewhat later maturity date than the U.S. commercial hybrids. The question now arose what would happen when Guatemalan germ plasm was brought to Iowa in three-way crosses and backcrosses.

In 1947 certain single crosses, three-way crosses and backcrosses with one Guatemalan parent were grown at Ames, Iowa, in order to study their growth and development in comparison with United States commercial hybrids. On Sept. 25, before frost, the trend in the plant height, ear height, leaf number and percentage of green leaves was greater in the hybrids than in the checks (commercial hybrids). Compare figs. 18 and 19. Note particularly the difference in development of the Guatemalan top cross and the U.S. commercial hybrid no. 13. The lodging was less, but the maturity was slightly later in the Guatemalan hybrids than in the U.S. hybrids. However, the hot dry weather of July and August definitely hastened the maturity of the U.S. hybrids and reduced the yield. The ears of most of the Guatemalan hybrids matured normally, with less apparent heat and drouth injury.

The eight single crosses made on inbreds Tr and 38.11 as ear parents varied in their response because in some there was highland germ plasm, in others coast and early dwarf; yet they all carried many green leaves and well developed mature ears. When the plants were pulled, their root systems were found to be larger and freer from root injury than the commercial hybrids. (See fig 20.) The four backcrosses (U.S. inbreds as ear parents) showed little loss of vigor. (See fig. 21.) Their vegetative and reproductive vigor was to be somewhat less than the three-way crosses, but equally as good as two of the U.S. commercial hybrids. (See ears of a backcross in fig. 22.) This response was better than anticipated and may open the way to introduce added vigor



Fig. 21. A backcross, 420x[(61dx) \times 420] growing at Ames on Sept. 25, 1947. Note the ears. Twenty-five percent of the leaf area was alive on the above date. The moisture content when harvested on Oct. 14 was 15.4 percent and weight per ear 0.49 pounds. Number 61d was a Guatemalan coast corn.

into U.S. inbreds. The four three-way crosses, three with highland and one with early dwarf Guatemalan parentage, looked very much like U.S. commercial hybrids in their vegetative and reproductive stages, but again there was little injury from the severe weather, and the ears

were well formed and large, 8 to 13 inches. (See fig. 23 and compare with fig. 19 as to their development and drouth tolerance.) Figure 24 shows the ears of two three-way hybrids, M14x(31axWF9) and M14x(WF9x31a). The 31a was an open-pollinated Guatemalan highland corn, probably a strain of the Nanne corn already described, and M14, and WF9 United States inbred lines.

The response of the three-way and the backcrosses was better than that of the single crosses. The three-way and backcrosses were earlier than the single crosses, and the vegetative and reproductive development of the three-way and backcrosses were in most of the cases superior to the U.S. corns. The quality of the grain was equally as good as that of the U.S. hybrids. Indications were that Guatemalan germ plasm of the highland, coast and mountain groups in hybrid combinations could be grown and studied in the corn belt in three-way and backcross hybrids.

On the basis of the number of green leaves per plant, height and grain produced, some of the three-way crosses seemed to be more heat and drouth tolerant, than the U.S. commercial hybrids used as checks. In 1947, the weather was unusually hot and dry during July and August which reduced the state yield more than 300,000,000 bushels below the 1946 yields. Naturally the plants with the best root system would provide the growing plant with the most water. On the other hand, the difference in number of green leaves on Sept. 25, might be explained on the basis of plant maturity. Too, difference in reaction to root parasites might be a contributing factor to the difference in number of leaves.

GUATEMALAN TOP CROSSES

The response of the United States inbreds, crossed with Guatemalan open-pollinated corns, suggested trying top crosses, comprising open-pollinated Guatemalan corns on one another. Such crosses were made in the winter crop of 1946 at Antigua. Some of these top crosses were grown in the spring of 1947 at Antigua and Tiquisate. There was wide variability in the response of the different crosses. The hybrids flowered and matured earlier than the parents. The leaf number, height and ear shoot development was

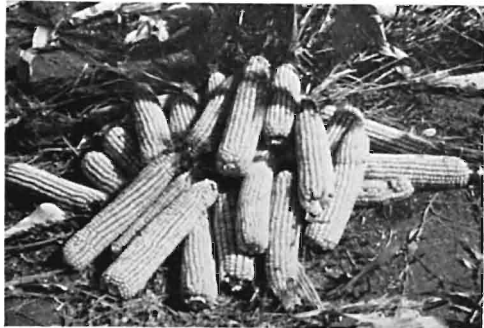


Fig. 22. The ears of a backcross growing at Ames and harvested Oct. 14, 1947. The backcross, M14x(M14x31) produced well filled ears, 8 to 10 inches long, with a moisture content 24.8 percent and an average dry weight per ear of 0.37 pounds. Collection no. 31 was a yellow highland open-pollinated corn.



Fig. 23. A three-way hybrid grown at Ames. Sixty percent of the leaf area was green and the ears were mature when photographed Sept. 25, 1947. The ears were 10-12 inches, dry weight 0.52 pounds and moisture 27 percent.



Fig. 24. Two three-way hybrids M14x(31axWF9) and M14x(WF9x31a) showing the large well filled ears growing at Ames in 1947. The ear characters are predominantly like those of the two U.S. inbreds in shape, length and kernel characters. The ear lengths were, in the order mentioned above, 8-13 and 10-12 inches, moisture content 29.7 and 27 percent, the average dry weight per ear 0.52 and 0.45 pounds respectively. The percentage of green leaf area was 50 and 60 percent on Sept. 25.

not much different from the female parent. The average functional leaf number in the hybrids involving the coastal corns ranged from 15 to 18; highland, 17 to 18; early dwarf, 15 to 16; and in the parents, 17 to 19, 18 to 20, and 15, respectively.

The yield trend favored the hybrids. The yield of the top 10 ranged from 32.3 to 44.6 bushels per acre. A coastal corn, 10A-46, was in four of the nine top yielding hybrids. The adverse growing conditions (rootworm injury) in the plot materially reduced the growth and development of these top crosses.

A NEW INSECT PEST ON MAIZE

There exists in Central America a serious insect pest of maize, the larval stage of a fly known as *Euxesta major* V.d. Wulp. This is an undescribed destructive pest of corn. The larva feeds down in the spiral whorl on the terminal growing point of the young plant. Many of the plants are killed before they are 6 inches tall and most of the rest are dwarfed and seriously malformed. (See fig. 25.) The characteristic symptoms of those that were not killed immediately, consisted of excessive stooling at the crown as a result of the partial destruction of a portion of the terminal growing point by the feeding of the larva. The life history of the insect was worked out. The maggot is not associated with the seed.

The maggot attacks teosinte in the same manner as the maize plant. Although a search has been made for other hosts, maize and teosinte are the only ones that have been found to date. Maize maggot injury is very prevalent from sea level to about 6,000 feet.

The matter of controlling this insect pest becomes of great importance in connection with any program of mechanized maize production in Central America. Considerable experimental evidence using wet and dry insecticides, including DDT and arsenate, has been accumulated during the past 2 years. The only insecticide that has shown real promise is BHC-50, a 6 percent gamma isomer of benzene hexachloride, diluted in talc, known in the trade as a gammexane, manufactured by John Powel Company of New York City.

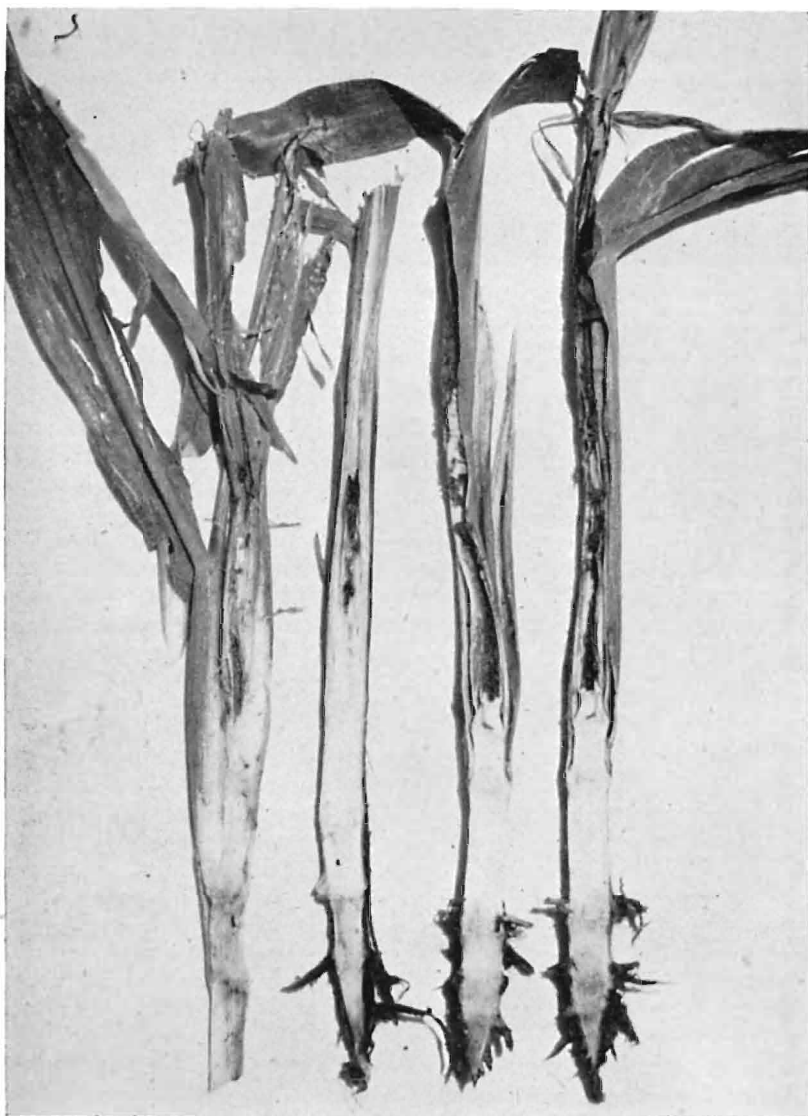


Fig. 25. This is maize maggot injury, caused by a fly, *Euxesta major* V.d. Wulp. The larva destroys all or a portion of the growing point of the seedling. When only a portion of the growing point is destroyed, the axillary buds develop resulting in a short, much-branched plant.

NEW DISEASES OF CORN IN GUATEMALA

The corn stunt disease is caused by a virus transmitted by a leaf hopper known as *Baldulus mardis*. The authors first discovered the disease in the Rio Grande Valley of Texas in 1946, and in the same year it was found for the first time in Guatemala. One of the character-

istic symptoms of this disease is the vigorous growth of the axillary buds into long lateral branches. Such plants resemble teosinte and teosinte-corn crosses, and may easily be mistaken for teosinte. It may well be that the prevalence of corn-teosinte hybrids reported in Mexico and Guatemala by some who have searched for the native teosinte confused teosinte-corn hybrids with the symptoms induced by this virus. (See fig. 26.)

TEOSINTE AND TEOSINTE-CORN HYBRIDS

Teosinte seems to be the closest known relative of corn. This plant has been previously reported in two localities of Guatemala, the Rio Huista Valley near San Antonio Huista and in the Progreso-Jutiapa section in southeastern Guatemala. In 1945, its range was extended into the Rio Azul Valley.⁴ In all locations, corn was extensively grown, yet teosinte-corn hybrids were not common. That they do occur has been definitely established, but there is no evidence that they maintain themselves under natural conditions. In fig. 27 are shown some teosinte-corn hybrids, collected in heavy stands of native teosinte. They have been repeatedly reported occurring in corn fields, where teosinte probably served as the male parent. There is no indication that corn has had any influence on the purity of teosinte, and there is much evidence showing that teosinte in the past was widely distributed within definite climatic zones in Guatemala and Mexico. Its occurrence in isolated areas is probably incident to the destruction of the natural flora following the advent of agriculture. There is



Fig. 26. The plants at the left and right are two different corns infected with a virus. The plant in the center is a teosinte plant. The branching of the corn plants is a symptom of the virus disease. The general character of growth of the three plants is similar. The ear characters are different which affords a quick method of distinguishing the diseased plants from the normal teosinte.

⁴In 1948 Dr. Wilson Popenoe sent seed from a collection made by one of his students near Pespira, Honduras. Later the same year Director General of Agriculture of Honduras, Señor Don Pampilio Vetigo, also sent seed from Pespire. However, in neither case was there positive evidence that the plant was indigenous. In June, 1949 teosinte was collected near El Prigress, Guatemala, growing along stone fence rows surrounding the fields. It was common in the region and doubtless indigenous.

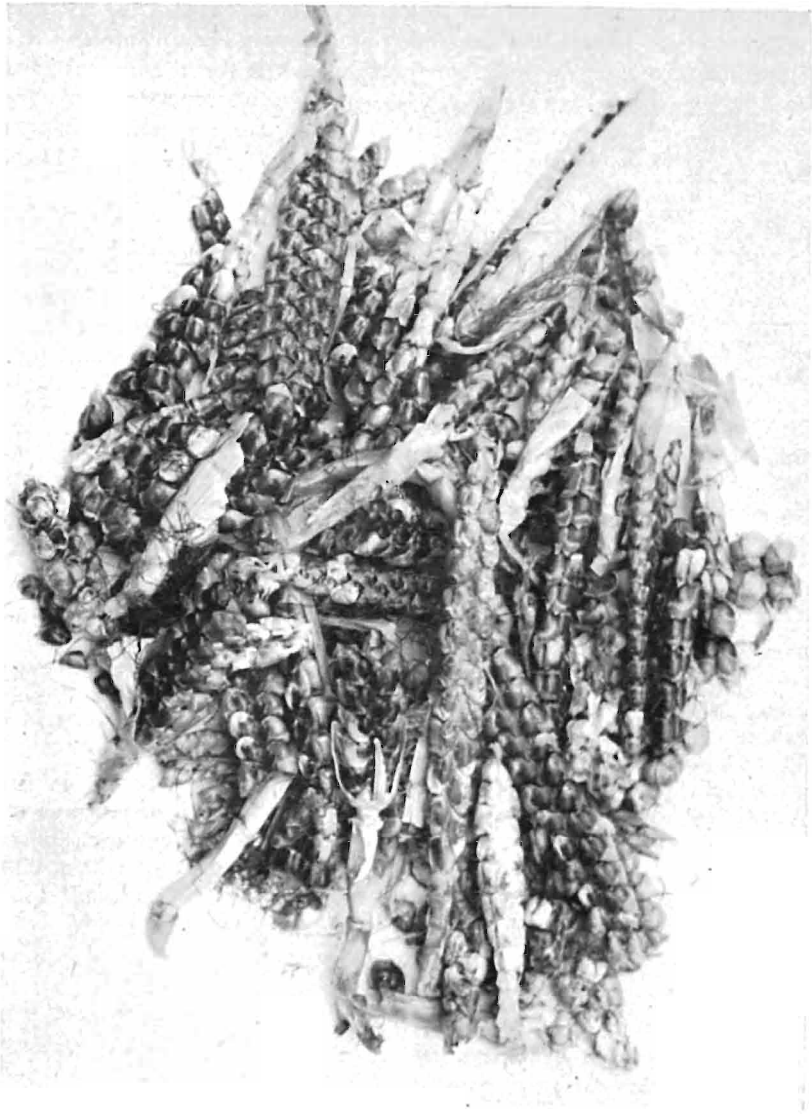


Fig. 27. Teosinte-corn hybrids collected in heavy native stands of teosinte near San Antonio Huista, Huehuetenango, Guatemala in 1946 and 1947. Note the 4- and 8-rowed grain instead of two rows typical of teosinte.

evidence that teosinte originated in Guatemala, but there is no evidence to support the assumption that teosinte originated in a specific place in Guatemala. Its coexistence with corn in isolated areas may well be the influence of climate and agricultural practices of the Mayan people.

Resumen De Los Estudios Sobre El Maíz En Guatemala

RESUMEN

POR I. E. MELHUS, J. R. WALLIN y GEORGE SEMENIUK
IOWA STATE COLLEGE-GUATEMALA TROPICAL RESEARCH CENTER

En el Año 1944 el estudio del maíz en Guatemala tuvo principio con una inspección preliminar que comprendió casi toda la república de Guatemala y algunos de los demás países centroamericanos y Méjico. Dicho estudio continuó en 1945 cuando se dispuso que la única manera de conocer el maíz de la región, era sembrarlo y seguir su desarrollo durante un periodo de tiempo más o menos largo. La impresión obtenida en 1944 y 1945 fué la de que en el trópico existía una gran diversidad y variabilidad de maíz. Las variaciones en sus caracteres vegetativos y reproductivos eran tan grandes que daban lugar a confusión, y aún las que ocurrían en campos pequeños eran muy marcadas y de difícil comprensión.

En 1946 se escogieron en Guatemala seis regiones de climas diferentes, todas dentro de un grado de latitud y con alturas desde 0 a 8000 pies. Estos lugares son: Antigua G. (4833 pies); Tiquisate (150 pies); Chocóla (2700 pies); Bárcena (4858 pies); Cobán (4200 pies); y Quezaltenango (8120 pies). La precipitación pluvial varía en estos lugares, de 575 mm. anuales en Antigua G., hasta 3000 mm. anuales en Cobán. Se cultivaron los mismos maíces, especialmente guatemaltecos en todas las regiones, bajo condiciones uniformes, para su estudio.

Los maíces se clasificaron con base en el estudio de 21 de sus caracteres, vegetativos y reproductivos, juntamente con su reacción en los diferentes climas a que fueron sometidos; de esta manera pudieron diferenciarse cuatro grupos, a saber: Maíces de tierra fría, de Montaña, de costa, y enano-tempranos. Por supuesto esta clasificación puede aplicarse solamente en Guatemala.

EN BUSCA DE CUALIDADES Y CARACTERISTICAS SOBRESALIENTES

Con los estudios hechos de las diferentes clases de maíz, nos fué posible evaluar su resistencia contra los insectos y enfermedades, el frío, la sequía y el calor, juntamente con su rendimiento.

UN MAIZ RESISTENTE AL GUSANO DE LA RAIZ

En una parcela experimental, en Tiquisate, en el verano de 1946, en un pedazo de terreno anteriormente sembrado de banano, y dejado al barbecho por un año, se sembraron 42 clases diferentes de maíz en cinco réplicas; el suelo estaba infestado con el gusano en cuestión, y como era de esperarse, se observaron grandes estragos; todos los maíces, con excepción de cuatro clases (dos de éstas con solo unas pocas

plantas sobrevivientes), murieron antes de la floración. De las otras dos clases, 7A-46 y 35A-46 la anterior resultó ser la mas resistente. Esta colección se originó de una mazorca seleccionada de la clase 35A-46, originalmente traída de Cuba por la compañía Agrícola de Guatemala. Además de ser resistente al gusano de la raíz, este maíz es de mayor rendimiento, el grano es duro, de color amarillo dorado, y sus únicos defectos consisten en lo pequeño de sus mazorcas y lo corto de sus pedúnculos. Este maíz podrá distribuirse en Guatemala en 1949.

UN MAIZ RESISTENTE AL *HELMINTHOSPORIUM TURCICUM* CAUSANTE DE LAS "ESTRIAS DEL MAIZ"

En las parcelas experimentales de Cobán en 1946, en las que se sembraron 45 variedades de maíz, se observó que una de ellas era mas resistente a las "Estrías del maíz," enfermedad causada por un hongo conocido con el nombre de *Helminthosporium turcicum* y la cual es muy seria en la región de Cobán, causando generalmente una pérdida del 5 al 25% de la cosecha de maíz, según la época de infección. En 1947 se descubrieron otras tres variedades resistentes a esta misma enfermedad cuyo plasma germinal puede ser de gran valor al ser incorporado a los híbridos de los Estados Unidos. Hasta la fecha no hay un solo híbrido en E.E.U.U. con resistencia a dicha enfermedad. Asimismo, Guatemala y los demás países latinoamericanos serán favorecidos con la utilización de este maíz.

Esta variedad de maíz se cultivó en mayor escala en Cobán y en Bárcena en 1947, habiendo permanecido prácticamente libre de la enfermedad, cuando los campos adyacentes presentaban daños de más del 25% del follaje total. Este maíz, es un maíz de tierra fría, con mazorcas grandes y delgadas, las que alcanzan de 30 a 45 cm de largo, con 10 o 14 filas de granos pequeños, duros y planos. En 1946, fué uno de los mejores 27 en un experimento llevado a cabo en Bárcena, y el cual incluyó 75 variedades, habiendo producido más de cuarenta quintales por manzana.

EL MAIZ NANNE

El maíz "Nanne," se dice haberse originado de un cruce entre un maíz amarillo de Wisconsin y un maíz guatemalteco cultivado por el extinto señor don Enrique Nanne, cerca de la ciudad de Guatemala. La semilla de este maíz ha sido distribuida por el ministerio de Agricultura en varias regiones del país. En las parcelas de Bárcena en 1946, éste fué uno de los 27 antes mencionados, produciendo más de cuarenta quintales por manzana. El porcentaje de encamado, esterilidad y pudrición seca (*Nigrospora*), fué bastante alto en 1947. Este maíz puede considerarse de valor para cruces con líneas puras de E.E.U.U.

REACCION DE LOS CRUCES ENTRE VARIEDADES GUATEMALTECAS Y LINEAS PURAS DE LOS ESTADOS UNIDOS, EN GUATEMALA Y IOWA

Los primeros cruces se efectuaron en el valle del Río Grande en Texas, en la primavera de 1945, usando doce líneas puras y polinizándolas con polen de maíz guatemalteco. En la primavera de 1946, estos cruces se sembraron en Antigua G. y en Shenandoah, Iowa, con el objeto de observar la influencia del maíz guatemalteco en el desarrollo de los híbridos. En Guatemala la parcela constaba de 88 híbridos sembrados al lado de 16 maíces padres, en terreno irrigado; los híbridos mas tempranos produjeron polen 59 días después de la siembra, y en general todos ellos florecieron por lo menos dos semanas antes que los padres guatemaltecos. En su conformación, los híbridos eran mas pequeños, con menos hojas; y mas uniformes en su floración, desarrollo de la mazorca, y altura de las plantas. Los caracteres de las líneas puras eran mas aparentes, especialmente en lo que al tamaño y forma de la mazorca se refiere, éstas son de forma cilíndrica con granos dentados, en vez de ser cónicas y con granos duros, como los maíces guatemaltecos. El rendimiento de los híbridos fué también mucho mas alto. En Shenandoah, se sembraron 56 híbridos, junto con las líneas puras y los padres de Guatemala, y fué muy grato notar que los híbridos maduraban antes de las heladas, el follaje era intermedio constando el de los híbridos de un promedio de 18 hojas funcionales (los híbridos de la región maicera de los Estados Unidos poseen de 14 a 18 hojas funcionales), los padres guatemaltecos 22 hojas, y cinco de las líneas puras 13.3 hojas. La influencia de las líneas puras en este lugar, fué considerable en lo que se refiere a altura, número de hojas, sistema radicular, forma de la mazorca y clase de grano, pero también aparecían en varios híbridos, las tusas ásperas y el pedúnculo corto de los maíces de Guatemala. Aunque aquí no se intentó medir el rendimiento de los híbridos, el tamaño y número de mazorcas por planta indicaba que este había de ser tan bueno como el de los híbridos comerciales de los Estados Unidos.

CRUCES ENTRE MAICES GUATEMALTECOS

Estos fueron hechos en Antigua, en el invierno de 1946, y algunos de ellos fueron sembrados en Antigua y Tiquisate, más tarde en 1947; como era de esperarse, también estos híbridos resultaron ser mas tempranos que los padres; el número de hojas, altura y desarrollo de la mazorca diferían muy poco de los mismos caracteres en el padre femenino. El promedio de hojas funcionales en los híbridos hechos con maíces de la costa era de 16.5; 17.6 a 17.8 en los hechos con maíz de tierra fría; y 15.4 a 15.6 en los que contenían maíz temprano; los promedios en los padres eran de, 17 a 19; 18 a 20; y 15 respectivamente. El rendimiento de los mejores diez híbridos fué 32.6 a 44.6 quintales por manzana. Un maíz de costa, 10A-46, formaba parte de cuatro de los nueve mejores híbridos. Las malas condiciones de cultivo en los lotes, redujeron considerablemente el desarrollo de las plantas.

UNA NUEVA PLAGA DEL MAIZ

Existe en muchas partes de Centro América, una grave plaga del maíz, la cual consiste en el daño causado por la larva de una mosca conocida con el nombre de *Euxesta major*, V.d. Wulp. Esta plaga aún no había sido reportada. El síntoma característico de las plantas atacadas, que no son destruidas inmediatamente, consiste en la producción abundante de hijos, debido a la destrucción parcial del meristemo terminal ocasionada por la larva al alimentarse.

NUEVA ENFERMEDAD DEL MAIZ EN GUATEMALA

La enfermedad del "Argenio" del maíz, es causada por un virus, transmitido por un saltahojas, el cual es conocido con el nombre de *Baldulus maydis*. Esta enfermedad fué observada por el autor, por primera vez, en el valle del Río Grande en Texas E.E.U.U. en 1941, y en el mismo año se descubrió por primera vez en Guatemala.

TEOSINTE E HIBRIDOS ENTRE MAIZ Y TEOSINTE

El teosinte parece ser el congénere mas cercano del maíz, que se conoce, y ha sido reportado de dos lugares en Guatemala, a saber: El valle del Río Huista, cerca de San Antonio Huista en Huehuetenango, y la región de El Progreso en Jutiapa. En 1945 se le encontró también en el valle del Río Azul, también en Huehuetenango. El maíz es cultivado en abundancia en estas tres regiones, pero los híbridos entre ambos son raros; y aunque se sabe ciertamente que ocurren no hay prueba de que se multipliquen bajo condiciones naturales. No se tiene ninguna indicación de que el maíz haya tenido alguna influencia en la pureza del teosinte; pero en cambio, sí se tienen pruebas de que el teosinte, en años pasados, crecía espontáneamente dentro de ciertas zonas climáticas en Guatemala y Méjico.

Su existencia en lugares aislados se debe seguramente a la destrucción de la flora natural con el advenimiento de la agricultura, y su coexistencia con el maíz en áreas aisladas puede muy bien ser el resultado de la influencia del clima y las prácticas del pueblo maya de antaño.

The Application of the New Method of Corn Breeding in Cuba

BY C. G. DEL VALLE

AGRICULTURAL EXPERIMENT STATION, SANTIAGO DE LAS VEGAS, CUBA

Maize in Cuba is a basic crop in the economy and maintenance of the small farmer. Nevertheless it is not a cash crop, and were it not for the many uses of its grain on the farm it would not be so commonly grown.

Next to sugar cane it is the crop most widely planted on the island and comprises the largest acreage. This varies annually from 250,000 to 300,000 acres, with an annual production of approximately 5 to 6 million bushels. The value of the crop each year in normal times is about 4 million dollars; at the present time it is worth 10 to 12 millions. The production per acre varies from 18 to 22 bushels. This shows the necessity of better seed and cultural methods as well as of better varieties, in order to make this crop more profitable.

The new method of corn breeding is based on the production of inbred lines, that is on the use of consanguinity as a means to control variation and to find individuals of superior germ plasm, where heterogeneity conceals the favorable recessive characters, the lethals and those that cause abnormalities. Afterwards, by crossing the most productive inbred lines and those of better combining ability, it has been possible to exceed the yields of the original variety as much as 30 percent.

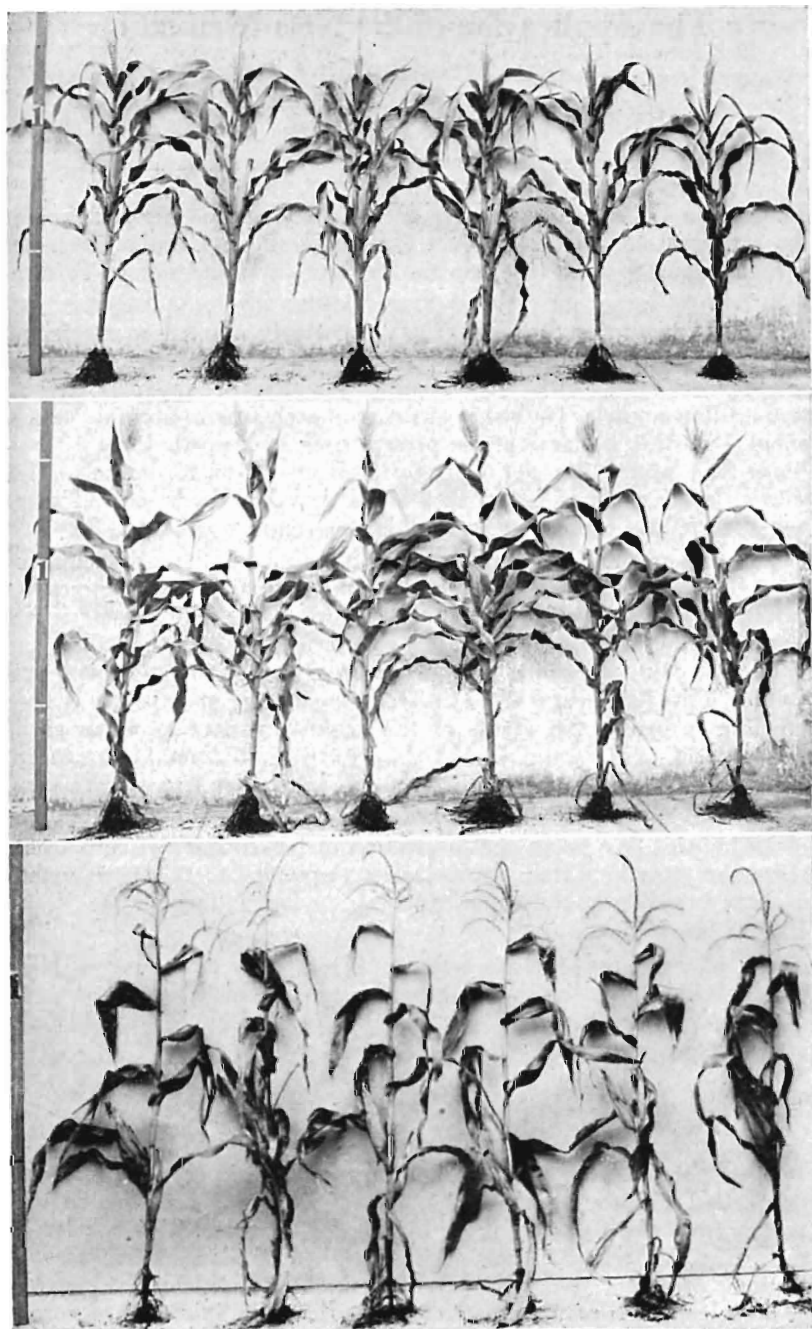
In Cuba this system had never been used for the improvement of corn yields, in spite of the rapidity of results and the high production of its hybrids. We began the production of inbred lines of corn to observe the ways in which tropical corn responded to this new method of corn breeding at the experiment station in Santiago de las Vegas, Havana, in 1936.

The plan of study was as follows: (1) to determine the possibility of obtaining inbred lines of corn; (2) to test and determine the uses of the inbred lines; and (3) to find the practical application in Cuba of this new system of corn breeding.

METHODS TO OBTAIN INBRED LINES OF CORN

There are two ways to obtain homozygous lines in corn: by the practice called sibbing, in which the silks of the ear are pollinated with pollen from the sister plant, or by autofertilization which consists of using for this purpose the pollen of the same plant. There are two methods of performing this operation: the bottle method developed by Jenkins,¹ and the regular method of artificial pollinization of cereals

¹Merle T. Jenkins, principal agronomist in charge of corn investigations, U. S. Department of Agriculture.



Figs. 1, 2 and 3. Inbred corn plants, representatives of three of the lines obtained. From top to bottom, lines 2-3, 2-5 and 2-4. (Photographs by Sotolongo.)

which may be called the paper bag method. The latter was adopted in our work because it is simpler and requires less material.

It was possible to practice selfing throughout the day, but the morning was the best time. Larger quantities of fresh pollen were available than in the afternoon. During the summer selfing could be started earlier in the morning than in the winter. It was necessary to allow 1 or 2 hours of sunlight for the tassel bags to dry from the heavy dew of the winter nights. Otherwise the pollen would clog or adhere to the moist parts of the bag. The winter or dry season, however, was the best time of the year to carry on the selfing operation as a whole or to maintain the inbred lines. The heavy and windy rains of summer tore and unglued many paper bags, thus spoiling a number of selfed ears. The excessive moisture also caused many ears to mold. During no season of the year was the temperature inside the tassel bags hot enough to kill the pollen grains and interfere with the selfing process.

METHOD OF SELECTION FOLLOWED WITH THE INBRED LINES

Since most of the corn varieties in Cuba are a mixture of the flint and dent types (*Zea mays indurata* Stutt and *Z. m. indentata* Stutt.) it was better to self 500 plants in a corn field and select in the barn the best 100 selfed ears according to their characteristics.

In the following selfings Jones² method was followed with some modifications.

The ears were planted ear-to-row in 10-meter rows, each with approximately 25 hills. Three kernels were sown in each hill and later thinned when plants were 6 inches high, leaving one per hill. Five plants were selfed in each row. At harvesting time the best of the five selfed ears was selected and kept for future plantings to continue the line. This process was repeated until the plants of the same row became equal among themselves and were homozygous in the different morphological characters, which generally happened from the fourth to the fifth selfed generation. Once the lines were homozygous, continued selfings did not change them in height, vigor or production. See results in table 1 and figs. 1, 2 and 3.

THE PRODUCTION OF ABNORMALITIES

With the continuous inbreeding, different kinds of abnormalities appeared. Some authorities do not believe that these abnormalities are the product of consanguinity since they are also observed in open-pollinated varieties of corn although less frequently. It is accepted that inbreeding prepares the road for these abnormalities while in open-pollinated varieties they are not seen so frequently due to heterozygosity.

During the selfing process the following abnormalities were observed: white, golden and zebra seedlings, and japonica striping in

²Donald F. Jones, Connecticut Agricultural Experiment Station.

TABLE 1. RESULTS OF CONTINUED SELFING IN MAIZE WITH REGARD TO HEIGHT OF PLANTS, NUMBER OF ROWS PER EAR, LENGTH OF EAR AND YIELDS.*

Variety	Number	Selfed generations	Plant height (inches)	Rows of grain on the ear (average)	Length of ears (inches)	Yields (pounds per acre)
Bayamo Dent	6-1	1	94	12.32**	5.83	856
		2	82	12.30	4.53	632
		3	68	12.21	4.37	512
Bayamo Dent	6-4	1	96	13.41	7.22	1,088
		2	74	13.71	4.16	547
		3	66	13.39	4.84	309
Bayamo Dent	6-5	1	105	12.80	6.18	1,004
		2	91	12.51	5.08	610
		3	82	12.87	4.33	428
Havana Flint	2-2	4	73	12.58	5.76	294
		5	75	12.92	6.69	323
		6	65	12.63	5.49	273
Havana Flint	2-4	4	50	8.38	5.16	225
		5	53	8.29	6.59	337
		6	45	8.21	6.10	253
Havana Flint	2-1	4	75	12.81	5.49	301
		5	77	12.65	6.33	350
		6	67	12.19	4.95	294

*Yields from three replicated plots. Each plot 30 hills.

**These figures express an average number of rows and not the number found on any individual ear.

larger plants; plants with sterile tassels, where the pistils failed to emerge, with both male and female organs sterile, and with different kinds of sterility due to atrophy of the male and female parts; plants in which the dehiscence of pollen was completed before the silks were out, and others in which the silks lost their receptivity before the pollen was shed. This latter type of abnormality caused the loss of some good lines. Ears were also observed with aborted grains and tassels with grains, and grains and silks in the central and lateral spikelets.

In more advance selfed generations different types of dwarf plants were found. In some the height reduction was due to a smaller number of nodes than in normal plants and in others to a shortening of the node space. These abnormalities were observed in different plants: forking stems, folding top leaves not permitting the tassels to protrude, zigzag stems, ear and tassel together in the upper portion of the plant, and ear and tassel together in the axil between the leaf and stem. Also plants were found with only the ear where the tassel should be, this abnormality being found in the top of the plant or in the axil between the leaf and stem. Other abnormalities were: very slender leaves, in which the blade of the leaf was almost limited to the width of the central vein; leaves spotted by necrotic areas and plants with the kernels at the base of the ear partially covered with glumes. After the inbred lines reached the homozygous state no more abnormalities were observed.

AVERAGE OF INBRED LINES OBTAINED FROM CORN VARIETIES

The percentage of good inbred lines that may be obtained from different corn varieties seems to be in direct relation to the number of years that the variety has been selected. This appears logical since with the continued selection there is an accumulation of characters favorable for production. Out of a total of 1,300 ears tested by us at the Experiment Station and obtained from Placetas, Palma Soriano, Holguín, Francisco, Bayamo and Santiago de las Vegas, 20 inbred lines were developed, that is 1.5 percent. However, only 9 of these 20 inbred lines were valuable. The rest were poor lines carried to homozygosity in order to have enough lines for the different crosses and to test experimentally (but not commercially) the value of the new method of corn breeding.

The flint type varieties produced larger numbers of inbred lines than the dent type. This may be attributed to the major resistance offered by the corneous starch of the flint kernel to weevil damage.

MAINTENANCE OF THE INBRED LINES OF CORN

Due to their state of homozygosity, inbred lines of corn are generally small, not vigorous and of low yields; they are difficult to maintain in the field under regular corn cultural practices and, unless special cultural attention is provided, they would not survive. When a proper rotation with some leguminous crop is not followed or other control measures used, the damage caused by the fall army worm (*Laphygma frugiperda* S. & A.) may result in the loss of many inbreds.

Another important factor is storage. To obtain a good hybrid, the yielding ability of the inbred lines should be determined as well as the best way to combine them. This requires two plantings for crossings and a yield test, all of which causes a delay of a year and a half, when two crops per year are grown. The power of germination in the inbred lines is weak and of short duration. Many of them do not germinate after a year. The difficulty of faulty germination can be avoided by planting every year, but this increases the maintenance cost and also prevents us from giving all of our attention to the testing of the lines. To overcome this difficulty, experiment stations in the United States provide cold storage rooms where viability can be retained for 3 or more years.

The cost of maintenance and yields of the inbred lines as well as the importance of the corn crop and its value in a given country are the main factors which will determine in the tropics the establishment of the production of hybrid seed corn for sale.

TESTING OF THE INBRED LINES

According to Jenkins, the productive ability of inbred lines of corn can be tested by crossing them with pollen of the variety from which they originated, crossing them with pollen of another variety, or with a mixture of pollen of inbred lines of the same or other variety. In our work each one of the inbred lines was crossed with the variety Victoria (Pl-F) from which none of them had been developed; furthermore, the inbred lines were used as male parents in the top crosses.

The yields of the top crosses were not always in direct relation with the production of the inbred lines. Inbreds of low yields sometimes gave hybrids more productive than the ones coming from higher yielding inbreds. Nevertheless, the most productive hybrids came from the highest yielding inbreds and the less productive ones from the inbreds of the lowest yields. See results in table 2.

TABLE 2. PRODUCTIVE ABILITY OF THE INBRED LINES OF CORN AS DETERMINED IN TOP CROSSES WITH THE VICTORIA VARIETY (Pl-F).*

Inbred lines	Yields of shelled corn (pounds per acre)		Top crosses
2-1	483	2,087	2-1 x Pl-F
2-2	393	1,917	2-2 x Pl-F
R2-2	346	1,849	R2-2 x Pl-F
2-4	324	1,870	2-4 x Pl-F
2-5	227	2,000	2-5 x Pl-F
R2-3	204	1,888	R2-3 x Pl-F
R1-1	134	2,055	R1-1 x Pl-F
R2-6	115	1,352	R2-6 x Pl-F
R2-5	67	1,731	R2-5 x Pl-F

*Yields from four replicated plots. Each plot, 20 hills. Necessary difference for significance: top crosses, 515 pounds per acre; inbred lines, 231 pounds per acre.

Since a low yielding inbred in top-cross combination with the Victoria variety was the second in production, the following question was raised: Can high yielding hybrids be obtained from low as well as high productive inbreds? In order to answer this question the inbred lines were grouped in good, medium and poor, according to their yields, and were crossed in all possible forms within their group. Good inbreds were considered those with a yield of more than 325 pounds per acre, medium inbreds those with a yield of 200 to 325 pounds and poor inbreds those with a yield of less than 200 pounds. In general the yields of the single crosses bore a relation to the production of their inbred lines. Two single crosses from medium inbred lines gave a high yield and a single cross from two inbreds resulted in a medium production. Nevertheless, there was no case in which a single cross from two poor inbreds gave a high yield or a single cross from two good inbreds gave a low yield. It was impossible to obtain enough seed from two poor inbreds to make the yield test of their single crosses. See the results in table 3, and figs. 4, 5 and 6.

On both ways in which the inbred lines were tested, an approximate indication of their productiveness in hybrid combinations was obtained.



Figs. 4, 5 and 6. Single crossed corn plants, representative plants of some of the hybrids obtained. From top to bottom, hybrids 2-1 x 2-2, 2-2 x R1-1 and 2-2 x 2-4. (Photographs by Sotolongo.)

TABLE 3. PRODUCTION OF SINGLE-CROSS COMBINATION CLASSIFIED AS GOOD, MEDIUM AND POOR ACCORDING TO THE YIELDS OF THEIR INBRED LINES.*

	Inbred lines	Yields of shelled corn (pounds per acre)		Single crosses
Good	2-1	483	2,385	2-1 x 2-2
	2-2	393	1,835	2-1 x R2-2
	R2-2	346	2,157	2-2 x R2-2
Medium	2-4	324	2,107	2-4 x 2-5
	2-5	227	1,947	2-4 x R2-3
	R2-3	204	1,481	2-5 x R2-3
Poor	R2-6	115	1,105	R2-6 x R2-5
	R2-5	67		R2-6 x R1-1
	R1-1	134		R2-5 x R1-1

*Yields based on five replicated plots. Each plot, 20 hills. Necessary difference for significance: 323 pounds per acre in the single crosses.

It can be said that the yields of the inbred lines give an indication of the productiveness of the hybrids that might be formed with them. This data can be used to discard the low yielding lines before they reach homozygosity. This saves time and work with lines that would not have future use and makes room at an early time in the program for more promising lines. The poor lines, besides their low production, increase the cost of hybrid seeds and make commercial production impossible.

The medium and good yielding inbred lines should be tested in some of the ways here studied before they are discarded. The good lines should be tried in different combinations before a commercial hybrid is made, because even if their single crosses are good, we do not know how they are going to behave with regard to other characters important in corn production, such as: healthy and erect plants, well filled and protected ears, good quality of kernels, etc.

NOT ALL HYBRIDS ARE MORE PRODUCTIVE THAN THE VARIETIES

Not all the hybrids give higher yields than the varieties, and in the cases in which their productiveness is only slightly better, their use is not justified. It remains to be determined in Cuba what is the necessary percentage of increase of hybrid corn over the varieties in order to be profitable for the farmer, considering the seed price and the production cost of the seed so that it is also profitable to the seed company.

As was stated before, the corn varieties with little or no selection produce a smaller number of inbred lines than the selected ones and as a general rule the inbreds obtained are less productive. Using Richey's practice of convergent improvement,³ some lines were improved in many characters by crossings with other lines and recovering them by selfings. It is expected that these improved inbred lines will give rise

³Richey, F. D. The Convergent Improvement of Selfed Lines of Corn. *Amer. Naturalist* 61:430-449, 1927.

to more productive hybrids than the ones obtained from regular selfed lines. Another practice that deserves trying in Cuba is the one of adapting, by the system of crossing and selfing with native varieties or lines, the best inbreds of other countries. The yields of different single crosses and corn varieties are given in table 4.

TABLE 4. YIELDS OF SOME SINGLE CROSSES AND CORN VARIETIES.*

Varieties	Yields of shelled corn (pounds per acre)		Single crosses
PD(MS)4	1,931	2,385	2-1 x 2-2
FD(MS)4	1,879	2,107	2-4 x 2-5
PF(MS)3	1,723	1,947	2-4 x R2-5
FF(MS)4	1,712	1,895	2-2 x 2-4
FF(MS)5 EEA	1,637	1,481	R2-5 x R2-3
PI-F(MS)11	1,597	1,461	R2-2 x R1-1
HD(MS)3	1,310	1,030	6-2 x W6-1
BD(MS)2	1,218	996	6-2 x W6-2

*Yields based on eight replicated plots. Each plot, 60 hills.

APPLICATION OF THE NEW METHOD OF CORN BREEDING IN CUBA

Due to the fact that Cuba does not have the best climate for corn production and that in the tropics the attacks of insect pests and diseases continue during all of the year, the production and maintenance of the inbred lines of corn is more costly and difficult. It has been noticed that the corn varieties of Cuba, due to the little selection that they have, give a low percentage of good inbred lines. In tropical regions there are few experiment stations producing inbred lines of corn with which an interchange could be made, as it is practiced among the experiment stations of the United States in order to increase every year the number of new hybrids adapted to new sections. Taking into consideration all of these factors, the new system of corn breeding could be best applied in Cuba by the following methods:

1. By combining 20 selfed ears of corn that in top crosses have outyielded the variety from which they originated.
2. By producing hybrid combinations with partially homozygous (two or three selfings) inbred lines. In this state of semipurity the inbred lines are more productive and easy to maintain.
3. By crossing 10 or 12 inbred lines to form a synthetic variety, after determining the productive and combining ability within the lines.
4. By adapting the most productive inbreds and hybrids of other countries by means of crosses and segregations.

RESULTS OBTAINED WHEN SOME OF THESE METHODS WERE USED

Using the ear-to-row system of selection, a number of ears from six different varieties were adapted rapidly to the field conditions of the Francisco Sugar Mill in Camagüey. By means of mass selection and pollen control, the flint and dent ears were separated and purified. This practice in addition to assisting in the unification of the types, improved the yields, because with the pollen control we not only

TABLE 5. YIELDS OF THE ORIGINAL FLINT AND DENT CORN VARIETIES IN FRANCISCO SUGAR MILL AND OF THE NEW ONES DEVELOPED BY THIS SYSTEM OF SELECTION.*

Types of corn	Yields of shelled corn (pounds)			
	Obtained		Estimated	
	Sq. meters	Pounds	Acre	Hectare
Dent	900	157.00	706	1,744
Flint	900	150.00	674	1,666
Difference		7.00	32	78
Dent	1,350	665.00	1,993	4,925
Flint	1,350	593.50	1,779	4,396
Difference		71.50	214	529

*Both yield tests were made in the winter.

knew the male parent, but by means of the pollen from selected individuals we were incorporating favorable characters for yields in the ears that were to be selected. In this form a flint and a dent variety were developed. One hundred ears were selfed in each, and after determining their yields in top crosses with another variety, the best 20 selfed ears of each variety were combined within their type. The flint and dent varieties resulting from this work were significantly better yielders than the original ones of that section. See results in table 5.

This table shows not only that the yields of the two new varieties are considerably better, but that the difference between the flint and dent types have also been increased, which indicates that the new varieties breed more true to type.

A synthetic variety was made at the Experiment Station by combining the seven best semi-homozygous (three selfings) inbred lines after determining their productivity in top crosses with a field corn variety. This synthetic variety was of the flint type and proved to be the best yielder in a test where six flint field corns were compared. (See results in table 6.)

In succeeding generations this synthetic variety had a lower yield than some of the field corns with which it was compared. It is be-

TABLE 6. COMPARABLE YIELDS OF SIX FLINT CORNS AND A SYNTHETIC VARIETY.*

Varieties	No.	Yields of shelled corn (pounds)		
		Obtained	Estimated	
		25 sq. meters	Acre	Hectare
Francisco Flint	1	12.50	2,024	5,000
FF(MS)6 EEA	2	14.00	2,266	5,600
Victoria Flint	4	9.44	1,528	3,776
Victoria de las Tunas	5	14.25	2,307	5,700
Canasi Flint	6	8.88	1,437	3,552
Hershey Flint	7	14.38	2,328	5,752
Synthetic Variety	8	16.25	2,631	6,500

*Yields based on five replicated plots. Each plot, 50 hills.

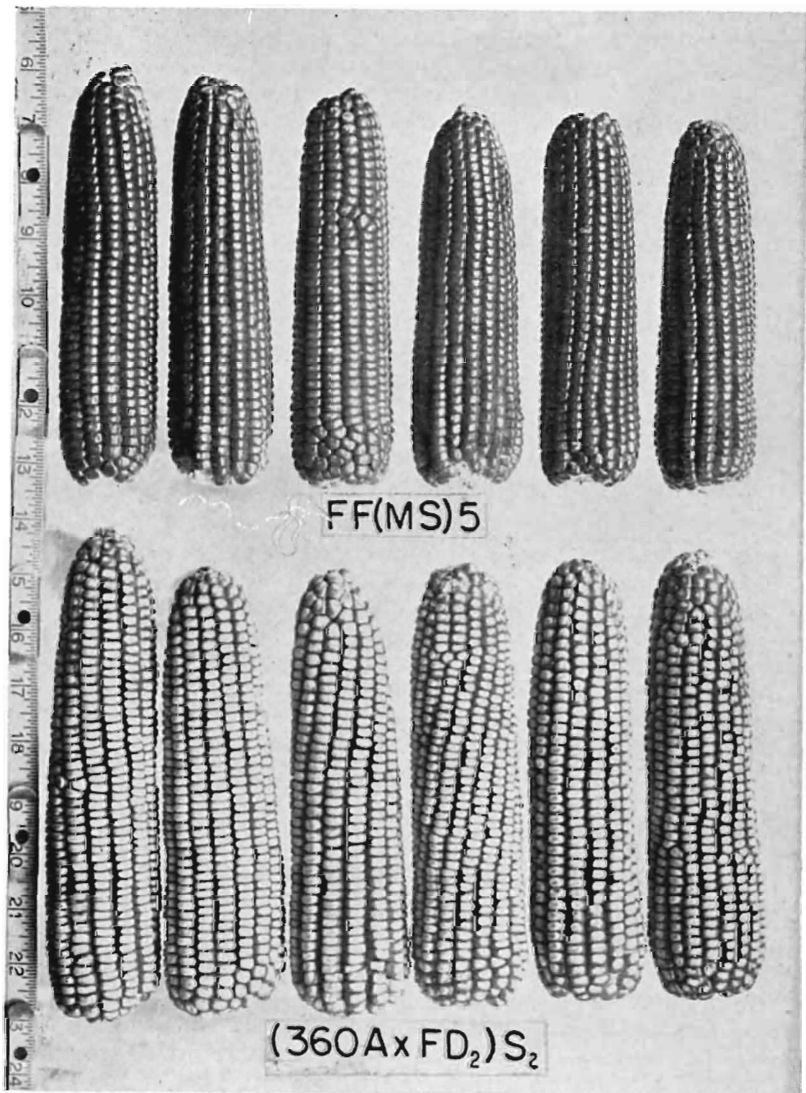


Fig. 7. Above, representative ears of the flint variety developed in Cuba at the Francisco Sugar Mill. Below, ears of Lester Plister hybrid 360A after adapting to Cuban conditions. (Photograph by Sotolongo.)

lieved that the high production shown in the first trial after its lines were combined was due to hybrid vigor or heterosis.

In considering this result it should be remembered that the inbred lines of the synthetic variety were not completely homozygous and that the combining and productive ability within the lines was not determined. Also, this is the result of only one synthetic variety;

therefore more trials are required before we can discard this method as efficient for corn improvement in Cuba. However, although theoretically it is possible to develop a synthetic variety more productive than the open pollinates, the United States experiment stations after a number of years of work have obtained few synthetic varieties more productive than the mass selected ones, and in the majority of them the yield differences are not significant.

An effort was made to adapt Lester Pfister's Hybrid 360A to the climatic conditions of Cuba. This hybrid was imported by the Francisco Sugar Mill Company to study its performance in Cuba and see if it would yield more than the original Francisco varieties. The idea was to have an early improvement in the production, before the two new varieties were developed. Hybrid 360A was tried in rich, black, clay-loam soil in spring and winter plantings, but its yields were always inferior to the local varieties (15 bushels per acre) and produced only second grade corn. The plants developed better in the spring plantings, but the quality of the grain was better in the winter, although the plants were smaller.

Part of the Hybrid 360A seeds, together with a local dent variety, were sown in an isolated plot. A cross was made using the hybrid as the male parent and detasseling the local dent variety. The seeds of this cross were crossed again with the dent variety, using the hybrid as the male parent. After these two crossings, three generations of segregation were allowed in isolated plots where the plants were interpollinated and roguing and plant and ear selection was practiced. The characteristic ears of the original hybrid 360A were easily found and selected. After the hybrid had been through this process it yielded 41 bushels per acre, about 3.3 bushels more than the most productive dent variety in Cuba. (See fig. 7.) When the hybrid 360A was recuperated by selfing and allowed to interpollinate afterwards, it never had the vigor and production that was obtained by the other process, although the other was slower.

Crossing well defined and homozygous varieties of different types also improved corn yields from 10 to 15 percent. The dent and flint varieties developed at the Francisco Sugar Mill were crossed to form a hybrid variety. The resulting corn was an intermediate between the two parents and according to its ear types may be called smooth dent. It shows a certain amount of hybrid vigor and the kernels are almost as resistant as the flint corn to weevil damage. Since it has a dark yellow color it is used in the manufacture of cornmeal⁴ and is more productive than the flint varieties. (See fig. 8.)

SUMMARY AND CONCLUSIONS

Some observations are made with regard to the selfing process in relation to weather conditions during the summer and winter in Cuba.

The field method followed to carry the lines to homozygosity is given.

⁴White cornmeal is almost never used in Cuba.

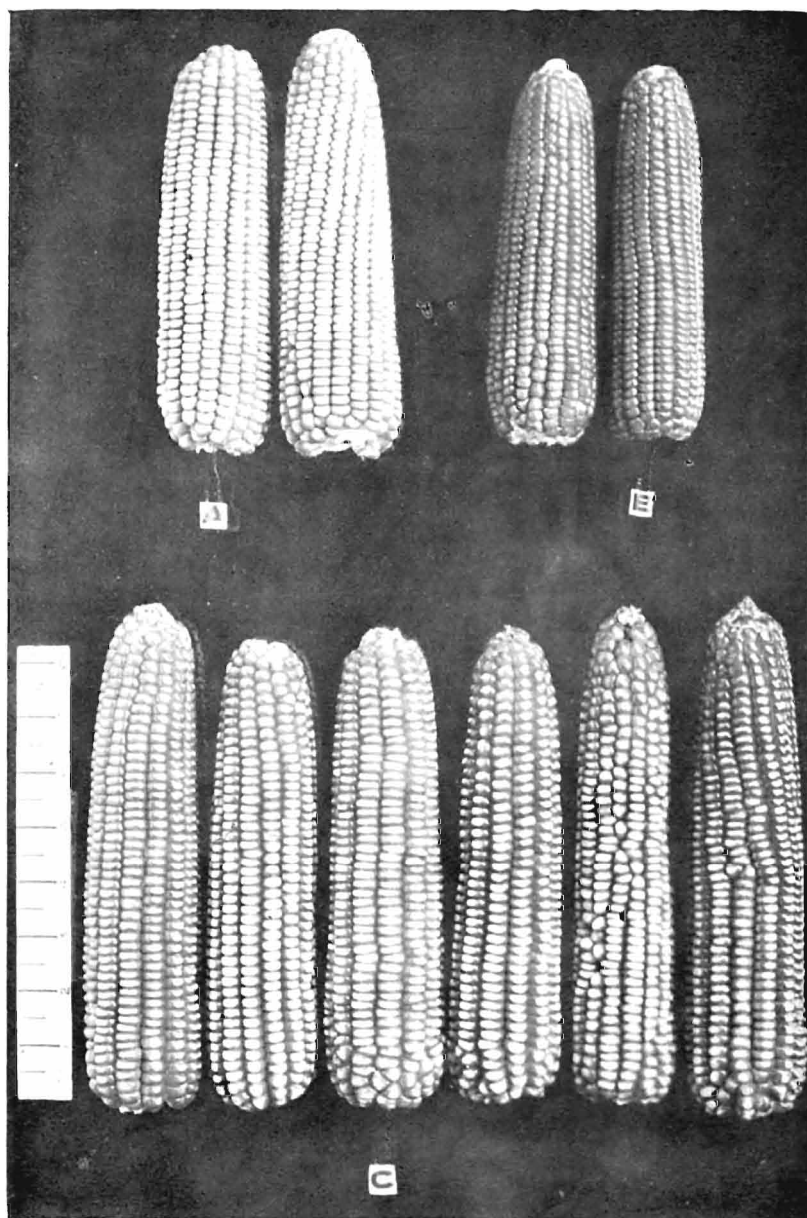


Fig. 8. Results of hybridization in corn. A and B are ears of two improved and well defined varieties. C shows the hybrid ears obtained by crossing A and B. The hybrid ears were of the smooth dent type and produced 15 percent more than the flint parent. (Photograph by Sotolongo.)

The different abnormalities produced with the continuous selfing or inbreeding are mentioned. Once the inbred lines were homozygous no more abnormalities appeared.

The average number of homozygous inbred lines obtained from corn varieties of different sections of the island was 1.5 percent.

It was found that once the inbred lines reached the homozygous state, special cultural practices were necessary in order not to lose them. It was easier to obtain and maintain the inbred lines during the winter months than in the summer.

The productive and combining ability of the inbred lines was determined in top crosses with the Victoria variety and by crossing them among themselves.

It was found that productive hybrids could only be obtained by combining inbreds of good or medium yields, but not of poor, and that the production of the inbred lines gave a good indication of the yield that may be expected from hybrids made with them.

Not all of the hybrids obtained were more productive than the field corn varieties.

It was demonstrated that a rapid way to improve the yield of a field corn variety was to self 100 ears, determine their production in top crosses with another variety and then combine the 20 highest yielding ears. This practice was also effective in adapting a variety to a new locality.

A synthetic variety made by combining seven proved inbreds failed to keep the high yield after the first generation. This practice of corn improvement, besides involving more work, did not prove as effective as other methods in increasing production. The practice of adapting hybrids from other countries by crossing, segregation, recombination and selection was satisfactory. The application of this system to hybrid 360A of Lester Pfister increased its yield from 15 to 41 bushels per acre after adaptation. Judging from this case it may be anticipated that this practice of adapting hybrids and inbred lines from other countries offers a promising future to corn production in Cuba.

La Aplicación Del Nuevo Método De Mejoramiento De Maíz En Cuba

RESUMEN

POR C. G. DEL VALLE

ESTACION AGRICOLA EXPERIMENTAL, SANTIAGO DE LAS VEGAS, CUBA

En esta publicación se hacen algunas consideraciones sobre la autopolinización del maíz, con relación al clima reinante en el Verano e Invierno en Cuba.

Se describe el método seguido para producir homocigosidad, al mismo tiempo se presenta una discusión sobre las anomalías pro-

ducidas por la autopolinización continuada, las cuales cesaron de aparecer cuando las plantas alcanzaron homocigosidad.

El promedio de líneas puras obtenidas de variedades de maíz provenientes de las diferentes secciones de la isla fué de 1.5%. Se descubrió que para conservar estas líneas puras, había que aplicar cuidados especiales, siendo mas fácil obtener y mantenerlas, en Invierno que en Verano.

El grado de combinación de las líneas puras y su rendimiento se determinaron por medio de cruces efectuados entre éstas y la variedad "Victoria," y entre ellas mismas.

Se observó que se podían obtener híbridos de alto rendimiento, siempre que se usaran líneas puras de rendimiento alto o mediano, y que, por consiguiente, el rendimiento de una línea pura es una indicación del que puede esperarse de los híbridos que con ella se hagan.

El rendimiento de los híbridos no fué en todos los casos superior al de las variedades comunes.

Se ha demostrado que un medio rápido de aumentar el rendimiento de una variedad común es el de autopolinizar 100 mazorcas de la misma, y determinar su rendimiento por medio de su cruzamiento con otra variedad y luego combinar las veinte mazorcas más productoras; este método es eficaz también para adaptar nuevas variedades en otras localidades.

El rendimiento de una variedad sintética, producto de la combinación de 7 buenas líneas puras, disminuyó considerablemente después de la primera generación.

La producción de variedades sintéticas para el mejoramiento del maíz además de requerir mas trabajo, no resultó ser tan buena como otros métodos, cuando se trata de aumentar el rendimiento.

La adaptación de híbridos de otros países a nuestro medio, por medio del cruzamiento, disgregación, recombinación y selección puede alcanzarse satisfactoriamente. Este método aplicado al híbrido 360A de Lester Pfister, aumentó su rendimiento, de 15, a 45 bushels (840 lbs. a 2520 lbs.) por acre al adaptarse.

A juzgar por estos resultados puede decirse que la adaptación de híbridos y líneas puras, de otros países, ofrece un futuro prometedor para la producción de maíz en Cuba.

Some Problems of Mechanized Maize Production in Guatemala

By ENRIQUE GARCIA SALAS

SUPERINTENDENT, MISCELLANEOUS CROPS, COMPANIA AGRICOLA DE GUATEMALA

Growing corn is a necessity for most of our people in Guatemala. It is a rich heritage of an ancient people passed down from father to son through thousands of years by the Indian population of the Latin Americas. Naturally corn has become a part of their life blood,



Fig. 1. Corn planting by the hoe culture method. Note the trash on the surface of the unplowed land and the pointed sticks for making holes in which to drop the seed.

daily lives, economy and religion. Likewise, the culture of corn is deeply rooted and primitive. The hoe is their most modern tool. Hoe culture, wherever featured, has a definite horizon of social progress, mainly because of the energy limits of the man working with so crude a tool. The number of man-hours required to grow enough corn for the family leaves little or no time for other pursuits of life, such as improvements in technology and education.

The limitations of hoe culture too have forced the Indian to follow bad practices. In clearing the land, fire is generally used to destroy the forest and bush. The corn is planted in the untilled cleared soil. The only planting tool is a pointed wooden stick with which a hole is made in the ground; seven or eight seeds are dropped in and covered with the foot. (See fig. 1.) The only cultivation that the crop receives is cutting the weeds with a machete twice during the growing season. Only the minimum amount of work is expended in growing the crop. The weeds are controlled only in part, which diminishes the yields. When the crop is mature, the stalk is doubled by bending the stalk over below the ear shank so that the ear (or ears) hangs down. This is an interesting practice dictated by necessity. Doubling saves the ears from the ravages of birds—parrots and *Sanates* (*Quiscalus marurus*). This practice also protects the ears from much injury from insects, plant parasites and fungus spoilage. However, doubling serves another important purpose. It hastens the drying of the ears.

This is especially important where a crop matures during the rainy season.

Generally the crop is allowed to remain in the field until it is sold or needed for food for the family. In other words, the land serves as a place to store the grain for a portion of the year. When the crop is harvested, the ears are gathered with the husks intact. The husks, in part, protect the ears from rain and rapid deterioration by insects and decay, because adequate storage for the harvested crop is not available to the majority of the small growers.

The harvested crop is carried on a man's back either to the house or to market. Often the distance the corn is carried is great. It is not unusual for the grower to carry the crop 5 or more miles to market. Thus the amount of human energy expended in producing the crop is great even though economy of effort is exercised in connection with each and every practice incident to the production of the crop. It is estimated that 100 man-hours are required to grow and harvest an acre of corn in Guatemala. In the United States, using modern machinery, it requires only 26 horsepower hours and four man-hours to produce an acre of corn. Still further, the machine method enhances the yield often more than 100 percent.

The above differences illustrate the limitations of human energy. Improved methods are not part of the philosophy of most small farmers in the tropics. But even if they were, the economic limitations would prevent mechanization of production.

Plainly, to increase food production and to advance socially, it is necessary to discard hoe culture and adopt, as other nations have done, the modern machine. However, to make this change brings into sharp relief many problems, and some of these will be discussed briefly here. Let us consider first whether mechanized crop production can become a practical procedure in this country. It is well known that we have done this in other agricultural production problems. In coffee we use steam or water as a source of power. Banana production is a highly mechanized production enterprise. Notable developments have been achieved in the last 15 years, especially in irrigation and spraying operations. Sugar cane production is a mechanized enterprise in part. If other crops can be and have been mechanized in this country, there is good reason to believe that corn production can also be mechanized.

Another question that might be raised is, "What effect will corn mechanization have on the economy and social development of the country?" In a country like Guatemala where agriculture represents its largest income, any improvement in methods of corn production will help the economy of the whole country. There are vast areas of fertile land which are not being used to their maximum capacity, that could be opened to crop production through the use of mechanical equipment.

The statement is sometimes made that in mechanizing corn production, the work will be taken away from the Indian. In this connection,

it is well to recall that the Indian is not a beast of burden. There are many jobs awaiting him, at better pay than raising corn with the hoe. Machine production will mean cheaper corn for the Indian. Lack of corn for tortillas stalks the household of the poor man every year. It is well known that the machine has cheapened rice production enough to permit its shipment from the United States to China at less cost to the consumer than the rice produced in China by human energy.

Many fear that if corn culture is mechanized, there will be a surplus of corn. In this connection it should be recalled that at present we produce hardly enough for human food. Much corn should be converted into high concentrates such as beef, pork, milk, butter, cheese, poultry and eggs. Abundant high concentrates make for a strong people. Also, it would be good for our country to have corn for industrial products, as starch, alcohol and oil. It is an established fact that corn finds its way into more than 500 industrial products, almost all of which Guatemala imports.

PREPARATION OF THE LAND

In selecting the land for growing corn mechanically, a good deal of thought should be given to soil erosion. Many of the areas now devoted to corn are unfit even for hand labor. Hillsides that are so steep that it is impossible to use any beast of burden to climb them, are now being used to grow corn. There are large areas in the lowlands and also in the highland plateaus where mechanization is practicable.

The first problem is clearing the land. Two methods can be followed: The first method is to clear it by felling the timber, letting



Fig. 2. Bulldozer clearing land for a fall crop of corn at Tiquisate. The land is level and lends itself to mechanized production. The brush, small trees and tall herbaceous plants are pushed into windrows and burned when dry. Photograph by I. E. Melhus, July 20, 1948.

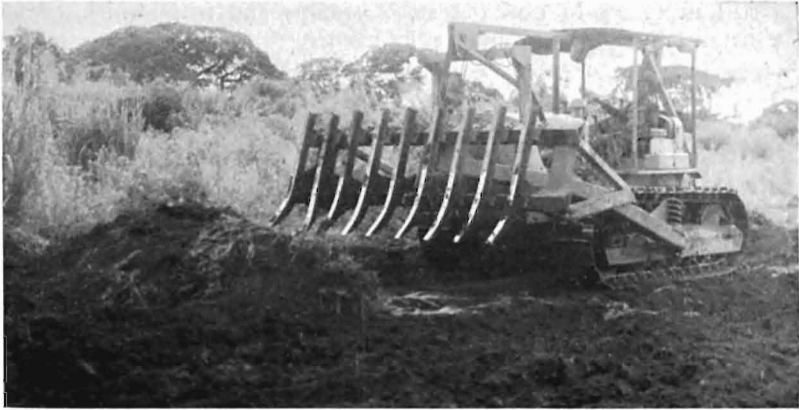


Fig. 3. After the brush and small trees have been scraped away into windrows, a root rake removes the larger roots missed by the bulldozer. Note the vegetation in the background that is being removed by the bulldozer and root rake. Photograph by I. E. Melhus, July 20, 1948.

it dry and burning it later, thus destroying many of the large trunks, and then avoiding all the stumps with light equipment. Large areas will be wasted in this manner for several years, and also there is a great risk of breaking valuable equipment. By this method, it requires many years to bring land into a high state of tilth. The second method is to use heavy mechanical equipment, bulldozers, stump pullers, rooters and root rakes, etc., in order to prepare the land in a short time for the use of lighter equipment. (See figs. 2 and 3.)

The cheapest way to bring new forest land into proper tilth for corn growing is to cut the underbrush and trees and let them dry for a long enough period to burn properly. After this burning it will still be necessary to use heavy equipment, such as bulldozers, root rakes, stump pullers and heavy plows. Naturally with all this equipment the operation, although a costly one, will be fairly simple if well trained men handle the machines. Our experience in this field is relatively small, but it is worth mentioning that although we are not equipped with all the desirable machines, we have been able to clear and bring into good tilth considerable acreage. We have used bulldozers to clear the land of trees and stumps. It has been found that by the use of the common bulldozer the soil is sometimes greatly disturbed because in pushing large stumps or tree trunks a large quantity of soil is also pushed with them. Therefore only short distances can be covered at one time, and it is often necessary to make windrows throughout the field, which thus becomes divided into sections. By using a heavy root rake less soil is moved and much more debris can be pushed out of the field in which the crop is to be grown. When only second growth is involved, it is a good practice to use heavy bush choppers, which resemble the cornstalk cutters and do very satisfactory work. The second growth will not decay fast enough to be plowed under, so it is necessary to use fire to destroy it. In most cases the root rake

is still necessary to pull out small stumps and roots which cannot be handled by plows or light equipment.

The purchase of heavy equipment for this type of work means a very large investment; one which the small farmer cannot afford. Either responsible contractors or government agencies will have to do this type of work for the majority of the farmers, as is done in the United States by local custom service. However, the cost of clearing the land is not unbearable when it is recalled that two crops can be grown in 9 months.

In newly plowed land, as a rule, insect damage may be severe, more so than in land which is cultivated by hand and where weeds are not destroyed. This is especially true where land is plowed and crops are kept free of weeds. Apparently the insects are not all destroyed in plowing. It may be that plowing early over a period of years will decrease the insect population. Early plowing is advisable also for weed control, permitting the field to be disked several times before the next crop is planted. The increased cost in land preparation will reduce the weed and insect problem in the growing crop. Power machinery will do much to raise the state of tilth of the land. It is believed that good farming practices will increase production quicker than anything else where new land is farmed.

PLANTING THE CROP

In planting corn, drilling will probably prove to be a better practice than checking in new land and in land not yet in a high state of cultivation. The time to plant corn in Guatemala is dictated by the coming of the wet season and the escape from insect seedling injury. A crop of corn cannot be grown during the dry season. It is possible, and common practice in certain areas, to plant a month to 6 weeks before the wet season begins. This permits the crop to pass its early stage of development before the rainy season begins. It also avoids much insect seedling injury by the maize maggot described by Harris and Melhus in the journal



Fig. 4. Corn planter drill attachment mounted on tractor frame and rig pipes of the cultivator. Note the disk covers mounted in front of the runner. This arrangement of attachments permits pushing the dry soil aside so that the runner works in the moist soil about 6 inches below the surface.

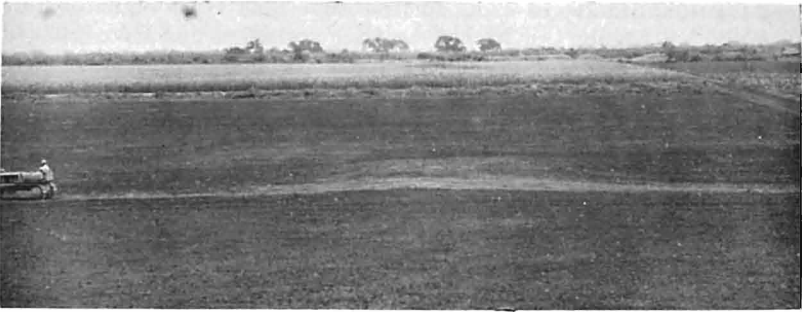


Fig. 5. One hundred acres of corn growing on newly cleared land at Tiquisate in 1948. In the foreground is land that is ready for planting. The land is flat and lends itself to mechanized production practices. Photograph by I. E. Melhus, July 20, 1948.

La Hacienda.¹ Planting during the dry season, when the soil is loose and dry, introduces problems not common to planting in the rainy season when the soil is firm and moist to the surface. The modification in arrangement of planter attachments is illustrated in planting a 20-acre field at Antigua, April 10 and 11 of this year.

The new John Deere planter attachment was used on land that grew a crop of corn the previous year and had been plowed in November. The soil was dry and very loose. The regular planter runner and packing wheels failed to plant and cover the corn deep enough to reach the moist soil, and stalks and other trash interfered with the runner and press wheels. This difficulty was overcome by using the disk covers in front of the runners and removing the press wheels. This rearrangement of attachments actually opened a furrow for the runner, prevented trash from interfering with the runner and covering knives, thus placing the seed in moist soil 6 inches below the surface of the loose soil. The position of the disk covers in front of the runners is shown in fig. 4. In firm clean soil this rearrangement would not have been necessary.

This rearrangement of attachments illustrates the modification necessary to adapt machinery built primarily for the corn belt conditions of the United States. Similar modifications often are necessary in other equipment. In fig. 5 is shown a 100-acre field planted by machinery and another 100 acres to be planted.

CULTIVATING THE CROP

Weed control is a major problem and often calls for modifications in the cultivator attachments. The Iowa State College Agricultural Experiment Station found that certain combinations of attachments produced much better results than others, depending on weather conditions, weeds to be controlled, etc. Similar studies will have to be

¹Harris, Halbert M. y Melhus, Irving E. Nueva Plaga Insectil de Maíz en C. America, La Hacienda, 43,6 :48-49,58. 1948.

made in this country in order to find out which types of cultivators give the best results. Our limited experience showed that the combined use of the disks as shields, sweeps or shovels and spring-tooth weeders, all mounted on the same cultivator bar worked quite well. The disk shields, if properly adjusted, gave better protection to corn and, at the same time, threw enough soil over the weeds growing in the row to smother them. The sweeps or shovels dug up the weeds but, if used alone, left enough soil on them to enable them to continue growing. The spring-tooth weeders brought the weeds up and even shook some of the soil from the roots so that there was more of a chance of destroying them.

Chemical weed control offers another avenue of attack on our weed problem. This is a new field of study even in the United States, where several chemicals seem to show good results. The application and use of weed killers in these countries will be different from that in the United States, but there is no doubt that they can be used to advantage. Preliminary trials in 1947 showed encouraging results.

In this country it will probably be necessary to cultivate corn more times than in the United States, at least until the perennial weeds are mostly destroyed. Certainly after a few years of clean cultivation, weed control should be much easier. This weed control deserves much attention in the tropics from practical farmers and research men.

HARVESTING THE CROP

Harvesting a corn crop by hand requires much labor, but by machinery it has become a rapid operation. However, if the mechanical corn harvester is to be used, fields must be free of stumps and stones and be properly planted and cultivated. The rows have to be uniform distances apart with room enough for the equipment. Much of the corn planted in Guatemala is in irregular rows. Also, the ears should be low enough on the stalk so that they reach the snapping rollers shortly after the plant is pulled in by the chains. The field should be free of weeds, especially morning glory and other vines, which easily clog the snapping rollers. Corn harvesters are expensive and complicated machines. Only skilled labor should be allowed to handle them. Serious accidents can occur if precautions are not exercised. Careless operators account for most accidents.

CORN STORAGE

With mechanized corn production will come the problem of curing and storing the crop. At present the farmers have little or no storage. As a result the grain is sold as soon as harvested. This means that the crop is sold on a glutted market. Later in the year the price may rise appreciably, but the average farmer will not benefit from the increase in price. With proper storage, the price can be stabilized to the advantage of the producer.

In storing corn several matters need to be taken into consideration. For instance, in the coastal plain on the Pacific slope, the harvest of the first crop is, as a rule, in August and September, during the rainy season. The moisture content of corn is too high for safe storage. The crop will need to be artificially dried before storing. At present the common practice is to leave the crop in the field until it has sun-dried. This is extravagant use of the land. The crop should be harvested and artificially dried as soon as mature, and the land prepared and planted to another crop. Such practice should increase the productivity of the land and lead to lower production costs.

The proper type of drying and storage equipment for the tropics has yet to be developed. Without doubt, some modification of artificial driers now used in the corn belt will need to be developed. A type of airtight storage bin may have to be used to permit fumigation. At the same time, enough insulation should be provided so that there is not a great change of temperature within the bin. Temperature changes lead to moisture condensation, which encourages storage molds and rots. Metal bins may prove practical if properly protected from direct sunlight and insulated enough to minimize temperature changes in the bin. Concrete or wooden granaries may prove superior to metal bins. The matter of corn storage in the tropics needs investigation. It is not so simple as in the corn belt.

SKILLED LABOR

Mechanized corn production calls for labor skilled in operating the machines and an understanding of the type of work the machines can produce. At present Guatemala has little or no skilled farm labor. Our labor knows only hand labor. In other words, we have the problem of training young men to become skillful in operating farm machinery. This is a formidable task and calls for the united effort of private enterprise and governmental agencies. Short courses should be instituted where boys might be schooled in the practical operation of farm machinery. This is not a novel idea; it is a common practice in the United States. Machinery companies and state schools conduct short courses in maintaining and operating farm machines. That this is a practical undertaking here in Guatemala cannot be questioned. Certainly such training would appeal to labor and enhance its earning capacity. If this can be done it will not be long before we will have a supply of skilled labor comparable to that in the corn belt of the United States.

Our farmers like machines, but they have not had an opportunity to use them. Naturally they know little about their operation. Most farmers in the United States are mechanically minded. They start working with tractors and other farm machines at a very early age. They take pride in being able to work with complicated machines and keep them in good repair. Having been around machines since childhood, it is only natural that these farm boys are well versed in the proper care and operation of machinery. It is a familiar sight on the farms in the United States to see children 10 to 12 years old driving tractors

pulling complicated machines. The rising generation in Guatemala can acquire this skill also if afforded the opportunity.

HIGHER YIELDING VARIETIES AND HYBRIDS

There are aspects of growing corn besides mechanization which need to be taken into consideration in order to make practical the use of expensive mechanical equipment. Most important of all is the development of high yielding varieties which will cut down the cost per unit weight. In developing new varieties of corn for mechanical cultivation, it is important to bear in mind that they not only have to be high yielders of uniform size and height, but also resistant to some pests and diseases. Drooping ears are more desirable than those that stand erect, because they are self protected against rains, insects, rots, birds, rodents, etc. The characteristics of the ideal type of corn are numerous and developing them is a problem that only corn breeders can solve. It will cost the same per unit area to grow a poor variety of corn as it will to grow a good one.

Isolation of our highest yielding varieties is not enough. It will be necessary to develop hybrids, adapted to the different localities, where mechanized corn production is practical. This work calls for specialists. Fortunately the staff of scientists of the Iowa State College-Guatemala Tropical Research Center is engaged in this work under the able leadership of Dr. I. E. Melhus. The Center is working in close cooperation with private enterprise and governmental agencies. It is the duty of all agencies in Guatemala and Central America to lend the Tropical Research Center their fullest support.

It must be realized that many problems will arise and need to be solved. A few of the problems that immediately confront the project, as pointed out above, concern not only power machinery, but also the training of personnel to operate the machines and solve the problems incident to growing the crop, storing and protecting the harvest from insect and mold damage. Undoubtedly there will be failures as well as good crops. These have and always will be present in pioneering the adoption of any new agricultural practice; but the reward, in terms of more food and social betterment, in Guatemala and the other countries of Central America, will justify the effort.

Algunos Problemas Del Cultivo Mecanizado Del Maíz En Guatemala

RESUMEN

E. GARCIA SALAS M.

SUPERINTENDENTE, SIEMBRAS MISCELANEAS, COMPANIA AGRICOLA DE GUATEMALA

Indiscutiblemente para aumentar la producción de alimentos y para que haya un progreso efectivo en el nivel de vida en general, es necesario descartar el azadón como implemento principal para cultivos y

sustituirlo, como se ha hecho en las naciones más avanzadas, con la maquinaria agrícola moderna. Sin embargo, al hacer este cambio se presentarían muchos problemas y son algunos de estos los que quiero discutir a grandes rasgos.

No me cabe ninguna duda de que en terrenos apropiados, la mecanización del cultivo del maíz en Guatemala será un éxito completo. Con frecuencia se pregunta; ¿qué efecto tendrá la mecanización del cultivo del maíz en el desarrollo social y económico del país?. En un país como Guatemala donde la agricultura representa su entrada mas grande, cualquier mejora que se haga en los métodos de producción del maíz, ayudará a la economía de todo el país. Hay grandes extensiones de terreno fértil que no se están aprovechando en toda su capacidad y que se podrían convertir en verdaderos centros de producción al usarse equipo mecanizado.

Con frecuencia se dice que al mecanizar el cultivo del maíz, se quitaría a los indígenas el trabajo. Respecto a esto quisiera hacer ver que hay muchos trabajos en los que se podían usar las energías de los indígenas, proporcionándoles mejores condiciones de vida y mejor remuneración. Con la producción mecanizada indudablemente el maíz resultaría más barato y por consiguiente convendría mas al indio comprarlo que producirlo. Es bien sabido que con la producción mecanizada, el arroz ha bajado tanto de precio que ha sido posible exportarlo de los EE.UU. a la China y venderlo allá a precios más bajos de lo que cuesta a los chinos producirlo.

Se teme también que con la mecanización podría haber exceso de producción de maíz. A este respecto conviene recordar que actualmente apenas si se produce en Guatemala suficiente maíz para alimentación humana. Mucho maíz podría convertirse en materias de mayor valor alimenticio, como carnes de res y de marrano, leche, mantequilla, quesos, huevos, aves, etc. Con estos alimentos al alcance de todos, mejoraría la salud y la energía de nuestros trabajadores. También convendría a nuestro país tener suficiente maíz para poderlo usar con fines industriales, como la producción de alcohol, aceite, etc. El maíz puede usarse como materia prima para más de 500 productos industriales, casi todos los cuales son actualmente importados en Guatemala.

PREPARACIÓN DE LA TIERRA

Una vez seleccionado el terreno, hay que ponerlo en condiciones tales, que no haya peligro de quebrar los implementos de cultivo con troncos o raíces. Sería largo enumerar aquí toda la maquinaria que debe usarse según las condiciones del terreno para dejarlo listo para el cultivo mecanizado. Baste decir que se requiere bastante maquinaria pesada y que la operación es costosa, pero que vale la pena gastar suficiente para dejar el terreno completamente listo de una vez, en vez de sacrificar la seguridad de la maquinaria más liviana y perder el tiempo cuando el terreno no está bien preparado.

Actualmente el sistema de siembra más comunmente usado es el "mateado," usando diferentes distancias, según el terreno y el lugar. Para las siembras a máquina, por lo menos al principio, me parece más práctico sembrar "surqueado," dejando de 36 a 42 pulgadas entre surcos y un promedio de 12 pulgadas entre las matas, en el surco. Para un tractorista inexperto, es más fácil hacer esta clase de siembra que la anterior y ésta facilita más las labores de cultivo y cosecha.

CULTIVOS

El problema más grave, es el de la maleza que crece en los campos de maíz. Con los implementos, tal como los fabrican ahora, no se destruyen totalmente las malas hierbas y posiblemente será necesario introducir algunas modificaciones en la maquinaria. Sin embargo, teniendo cuidado de no dejar crecer la maleza, usando las cultivadoras todo lo que sea necesario, se logra mantener los campos bastante limpios. Conviene tener presente el uso de productos químicos para la destrucción de malezas. Aunque hasta ahora no se han hecho más que ensayos sobre el uso de estos productos químicos en Guatemala, los resultados obtenidos indican que se podrán llegar a usar muy provechosamente en muchos de nuestros cultivos.

COSECHA

Cosechar maíz a mano requiere una gran cantidad de jornales. En cambio, haciéndolo a máquina es una operación rápida y efectiva. En todos los centros de producción de maíz se usan ahora cosechadoras. En Guatemala las hemos probado ya, con resultados muy satisfactorios.

GRANEROS

Con la mecanización del cultivo del maíz, se presentará el problema del almacenamiento. Actualmente, podría decirse que en Guatemala casi no hay almacenes apropiados para guardar maíz por tiempo indefinido, sin peligro de que éste sea dañado por insectos o por la humedad.

El establecimiento de graneros apropiados, para que sea verdaderamente efectivo, requiere ser estudiado en todos sus aspectos. Es básico asegurarse que el maíz no se almacene excesivamente húmedo y que esté bien protegido contra todos los insectos que lo atacan. Las cosechas de maíz que se sacan en Agosto y Septiembre, en la costa, generalmente tienen demasiada humedad para almacenarlas sin peligro. Para este maíz, posiblemente será necesario usar secadoras artificiales.

HIBRIDOS Y VARIEDADES DE ALTO RENDIMIENTO

Para que el uso de maquinaria tenga un resultado económicamente práctico, es indispensable usar semillas seleccionadas de alto rendimiento. Los mejores resultados se obtendrán cuando se logre producir

híbridos en Guatemala comparables a los que se cultivan ahora en los Estados Unidos. La producción de estos híbridos requiere laboriosos trabajos de investigación científica. En Guatemala ya se ha logrado avanzar mucho en este sentido gracias a la encomiable labor del Dr. I. E. Melhus y sus colaboradores en el Tropical Research Center. Mucho de su trabajo se está haciendo en terrenos de la Compañía Agrícola de Guatemala, que coopera con el Dr. Melhus en Tiquisate y creemos que en un futuro próximo, se habrán desarrollado híbridos adecuados a nuestro medio.

Corn Diseases in Guatemala

BY ALBERT S. MULLER

DIRECTOR, ESCUELA NACIONAL DE AGRICULTURA

From sea level up to altitudes of 8,000 feet, wherever corn has been seen growing by the writer during the last 7 years, there have been observed various diseases commonly present in the United States and elsewhere and others of rare occurrence. Although Guatemala is small in size, there are diseases of corn prevalent in the fields during the entire year, since, due to altitude and corresponding climatic differences, corn is planted in some parts at the same time it is being harvested in others. On the Pacific coast, where three crops a year are possible in the lowlands, corn diseases have a most favorable situation for spreading, since corn at different stages of growth is present in the fields nearly all year round.

FOLIAGE DISEASES

Generally, foliage diseases do not show up early in the growing period on corn in Guatemala, but only after the plants are several months old. However, if early maturing corn is planted in a field adjacent to a late maturing variety, foliage diseases will become prevalent in the former as much as a month sooner than in the latter. Ordinary corn rust, *Puccinia sorghi* Schw., although usually late in appearing, has been observed to be extremely destructive in fields of corn only a foot high that were planted in September (or out of season, in the highlands where planting time normally is in May). At the same time adjacent plantings of the same variety, well along toward maturity, were only beginning to show some rust. Two cases have been observed of lowland varieties of corn being severely damaged by ordinary rust when planted in the highlands in fields alongside of highland corns which were only slightly affected at the time and which matured without damage. This occurred in Barcena in 1945 and in Quetzaltenango in 1946. To account for this we may suspect that a different biological strain or strains of the rust pathogen may exist on corn in the highlands against which lowland corns have no resistance.

As the growing period advances, either in the lowlands or highlands,

the foliage disease which first draws attention is the stripe disease, *Helminthosporium turcicum* Pass. Gray-brown stripes appear, few to many per leaf, varying in size, but generally within $\frac{1}{2}$ to 1 inch in width by 1 to 6 inches long. The underside of the stripe frequently takes on a greenish hue, from the presence of abundant spore masses formed on the dry dead tissue. In plantings of a large number of varieties of corn, such as the Guatemala-Iowa State College Research Center has made annually, great differences are evident in the resistance toward this pathogen. The stripes usually appear on the oldest leaves first and, in severe cases, not even the newest leaves are free of stripes, which elongate and unite into continuous areas of dead tissue, resulting in the rapid drying out of all the foliage. This disease causes considerable damage every year, and is capable of causing great losses in such years as combine the most favorable weather conditions for its development and spread. At least one case of complete crop failure is known in the Alta Verapaz region of Guatemala in 1942. The search for and development of corn varieties resistant to this disease is imperative.

The ordinary corn rust, *Puccinia sorghi* Schw., mentioned above is usually a little later than stripe in appearing. It may be recognized by the presence of reddish-brown, minute pustules, produced in large numbers on the upper sides of the leaves. A dusty powder appears on the finger when it is rubbed over an affected area of the leaf. As the disease progresses many pustules unite and cracks appear, especially when a hard blackish spore form begins to develop in the pustules. In general the disease starts in the older leaves which die first. The question of biological strains of the pathogen ought to be investigated and the search for resistant varieties undertaken.

Guatemalan corn rust, *Angiospora pallescens* (Arth.) Mains, is different from ordinary corn rust. While widespread in Guatemala, it is not found outside of Central America and the Caribbean area so far as the writer is informed. In the highlands the disease has never been absent from the fields during the last 7 years, but has never been very destructive. In lowland corns on the Pacific coast severe damage was seen in September of 1947. As in ordinary corn rust, this disease appears on the leaves in the form of pustules. The pustules of Guatemalan corn rust are of two kinds: The first appears as minute cream-colored pustules breaking out on the upper side of the leaves in great numbers. The second kind of pustule, which develops later, looks like a purplish blotch with a cream-colored center, measuring about $\frac{1}{4}$ inch in diameter, circular or oblong in form. No variety of corn has been observed to be especially susceptible or resistant as yet. This is a disease about which not only do we lack knowledge of control, but also, because of its newness to science, we have almost no information regarding the biology of the pathogen.

Three other foliage diseases are prevalent in corn in Guatemala without falling into the category of serious diseases. One is tar spot, *Phyllacora maydis* Maubl., recognizable by the presence of numerous

black incrustations, $\frac{1}{8}$ to $\frac{1}{4}$ inch in diameter, on the upper side of the leaves. The second is characterized by narrow streaks of brown dead tissue, $\frac{1}{8}$ inch wide by 1 to 2 inches long, and is caused by the fungus *Cercospora sorghi* Ell. and Ev. The third is distinguished by brownish blotches, quite large and irregular, on the leaf sheath and base of the leaves, also internodes. It is caused by the fungus *Phyoderma zae maydis* Shaw.

SMUT DISEASES

Two kinds of corn smut are found in Guatemala. One of them, the common boil smut, *Ustilago zae* (Beck) Unger, annually destroys from 1 to 2 percent of both highland and lowland corn. In 1947, the writer's attention was called to the high percentage of diseased inflorescences in certain varieties in the experimental field of the Research Center in Antigua. These inflorescences have been transformed into black powdery masses by a different smut fungus, *Sorosporium reilianum* (Kuhn) McAlpine, which also accounted for the loss of 1 percent of the ears. An ear of corn affected by *Sorosporium* smut is top shaped with a rounded base, and tapers to a point, showing no external sign that within the tight encasing husks the interior has been transformed into a black powdery mass of spores. The boil smut readily announces itself to the observer, since it produces swellings of the affected parts of the ear, which burst out of the husks. The swollen kernels at first are covered by a whitish membrane, which later disappears exposing a black powdery mass of spores. Differences have been observed in the resistance of varieties to boil smut fungus in the Barcena plantings of several hundred varieties by the Research Center.

VIRUS DISEASES

A virus disease, affecting the entire corn plant, stunting it, and altering greatly its normal characteristics, has been observed by the writer every year since 1941 in various parts of Guatemala. The stunt disease may be recognized by the bushy appearance of the affected plant, resulting from the exaggerated growth of shoots from many of the nodes, together with a shortening of the internodes and reduction in size of the leaves. Not all affected plants show dwarfing, apparently some having been affected at a late stage, but not so late that they do not show the same color abnormalities seen in foliage of dwarfed plants. Affected plants have a lighter green foliage than healthy plants, and lengthwise of the leaves run long pale yellow or whitish bands or streaks, while the margins of the leaves become progressively bronzed or reddened towards the tips. Foliage of affected plants dies out much earlier than foliage of healthy plants. Almost no good ears are found on early affected plants, while on late affected plants a few normal ears develop. Since 1946 this disease, as well as several other diseases of virus origin, has been the object of investigation by the Research Center in Antigua.

EAR DISEASES OR EAR ROTS

During the harvesting of corn in Guatemala, what appear to be normal good-sized ears are usually brought in and stored separate from under-sized, inferior-quality ears. The latter, called the *mulco*, are used up first and do not become a source of seed, fortunately, because a majority of them are diseased. Often, small diseased ears are left on the stalk. Even among large ears, a dangerously high percentage may be affected with ear rots of various kinds, and it is important to recognize each kind. Ear rots reduce weight, impair quality and even flavor. Seed coming from diseased ears is also diseased, and often will not germinate at all, or at most produces weak useless plants serving as a carrier of disease from one season to another. Infected seedlings, many of which die right away, serve as a source of infection for the healthy plants adjacent to them.

Dry rot, sometimes called white rot, *Diplodia zeae* (Schw.) Lev., has been found regularly affecting about 5 percent of the ears harvested in dry years, but in 1947, when the rains lasted till December in the highlands the disease was more serious, affecting from 10 to 20 percent of the ears. Dry rot usually progresses from the base or butt toward the tip. The kernels lose their shiny luster, and white corns become a dirty yellowish brown. Often, between the kernels can be seen a white mat of fungus threads or mycelium, which also makes the inner layer of husks stick to the grains of the ear. Affected ears even when large, often do not weigh half so much as similar healthy ears. Dry rot is more serious in soft white dent corns than in any other type of corn and least serious in hard yellow flint corns.

Pink rot, *Fusarium moniliforme* Sheld, typically starts at the tip and progresses toward the base. Generally about 1 to 5 percent of the ears harvested are affected but this estimate is low in cases where ear worms have been abundant and entered the tips of large numbers of ears. Pink rot is conspicuous on white ears where both the kernels and cob turn pink or reddish brown. As with dry rot, seedlings coming from infected seed are infected and die, before or after emerging from the ground, while a high percentage of seed does not germinate.

Cob rot, *Nigrospora sphaerica* (Sacc.) Mason, is a sickly yellow colored rot, easily detected at the base of the ear. Whereas, in dry years cob rot is not found on more than 1 percent of the ears harvested, in the wet year of 1947 in Barcena, some 30 percent of white corn ears were attacked. Because of this rot about one ear in every three had to be discarded in selecting healthy ears for seed. In an infected ear, the end of the cob is yellowed, shredded, and the kernels are usually loosely attached. Often the rotted tissue is blackened by masses of spores imbedded in it. Black spore masses may be seen on some of the kernels.

Certain other fungi causing rotting of the kernels on the ear may be found on corn that has been under wet conditions either before or after storage. Infections such as these are usually restricted to a limited section of a few rows and frequently accompany an original in-

sect injury. Except for seed, there are no serious crop losses caused by these fungi, as compared with the three specific ones described above. The mold fungi which produce minor rots on ears, include a species of *Penicillium*, *Aspergillus niger* and *Rhizopus nigricans*, distinguished by the greenish masses of spores found on rotted kernels and cob.

CONCLUSION

By describing separately the diseases of corn commonly present in Guatemala, the writer calls attention to the fact that the corn grower is the victim of losses due to a number of different causes. These losses tend to increase when the grower is ignorant of the existence of the various kinds of diseases in his fields and uses practices that may increase instead of decrease their spread.

Some of the corn diseases in Guatemala are new to science and require careful investigation before methods of control can be recommended. Many practices useful in keeping other diseases under control are known, but these practices are not used because the diseases are not recognized by the grower. In some cases the best possible means of control is the use of resistant or immune varieties, which either can be sought for amongst the thousands of kinds of corn growing in Guatemala, or obtained as a result of investigation in the Iowa State College-Guatemala Tropical Research Center or in similar scientific institutions.

Enfermedades Del Maíz En Guatemala

RESUMEN

ALBERT S. MULLER

DIRECTOR, ESCUELA NACIONAL DE AGRICULTURA, GUATEMALA, C. A.

El autor ha observado que en Guatemala a pesar de su pequeña extensión, existe un gran número de enfermedades del maíz, comunes a otras partes del mundo, las cuales disfrutan de un medio muy favorable para su desarrollo, puesto que en Guatemala el maíz se encuentra en todas etapas de crecimiento durante todo el año.

ENFERMEDADES DEL FOLLAJE

Entre éstas se pueden contar las siguientes: *Roya común del maíz* causada por el hongo *Puccinia sorghi* la cual ha sido observada en plantas de un pie de altura, sembradas en Septiembre, o bien fuera de tiempo, en las tierras altas; ataca especialmente los maíces de costa. Está caracterizada por la presencia de gran número de pequeñas pústulas de color amarillo rojizo las que más tarde cubren toda la hoja y la destruyen. *Roya de Guatemala* producida por *Angiospora pallescens* (Arth.) Mains. Esta enfermedad existe solamente en la América Central y el Caribe, causa daños de alguna importancia pero nunca de mucha gravedad; las pústulas son de color morado negruzco con centro

blanco. El organismo causante ha sido poco estudiado. *Estrias del maíz* causada por *Helminthosporium turcicum* Pass. se caracteriza por la aparición de estrias de color pardo en las hojas, en cuyo envés se desarrollan las esporas. En 1942, esta enfermedad ocasionó la pérdida de la cosecha de maíz en la región de Alta Verapaz. Otros hongos, como *Phyllacora maydis* Maubl.; *Cercospora sorghi* Ell. y Ev. y *Phyoderma zea maydis* Shaw. producen enfermedades de las hojas, pero hasta la fecha no han sido de mayor importancia en Guatemala.

CARBON DEL MAIZ

Esta enfermedad puede ser causada por dos organismos distintos presentando síntomas diferentes, a saber: *Ustilago zae* Berck. y *Sorosporium reilianum* Kuhn, el primero se caracteriza por la presencia de agallas, las que contienen las esporas; y el segundo ataca la mazorca y la flor masculina en forma poco visible exteriormente.

ENFERMEDADES PRODUCIDAS POR VIRUS

El "argenio" del maíz es atribuida a un virus, fué observada por el autor en 1941; su síntoma principal es el desarrollo vigoroso de ramas laterales, deteniendo el desarrollo de la planta, las hojas presentan largas rayas amarillas en toda su longitud. No es de mucha importancia.

PODREDUMBRE DE LAS MAZORCAS

Pueden ser causadas por tres organismos, a saber: *Diplodia zae* (Schw.) Lev.; *Fusarium moniliforme* Sheld. y *Nigrospora sphaerica* (Sacc.) Mason. La primera es llamada podredumbre seca, la segunda, podredumbre rosada, y la tercera podredumbre del olote. Estos hongos atacan la planta en general y las mazorcas en particular evitando su desarrollo normal; son causa de pérdidas de poca importancia. En 1947, la última se encontró atacando un 30 por ciento de la cosecha, en Bárcena.

Se han reportado otros hongos, como *Penicillium*, *Aspergillus niger* y *Rhizopus nigricans*, como causa del deterioro del maíz almacenado pero sus daños no son de mucha consideración.

Research Contributions from Iowa State College-Guatemala Tropical Research Center

A New Insect Pest of Maize in Central America¹

By I. E. MELHUS AND HALBERT M. HARRIS

DIRECTOR, IOWA STATE COLLEGE-GUATEMALA TROPICAL RESEARCH CENTER
HEAD, DEPARTMENT OF ZOOLOGY AND ENTOMOLOGY, IOWA STATE COLLEGE.

There exists in many parts of Central America a serious insect pest of maize, the larval stage of a fly. The larva feeds down in the spiral whorl on the terminal growing point of the young plant. The injury is well known to the Indian farm, but it is unknown to science.

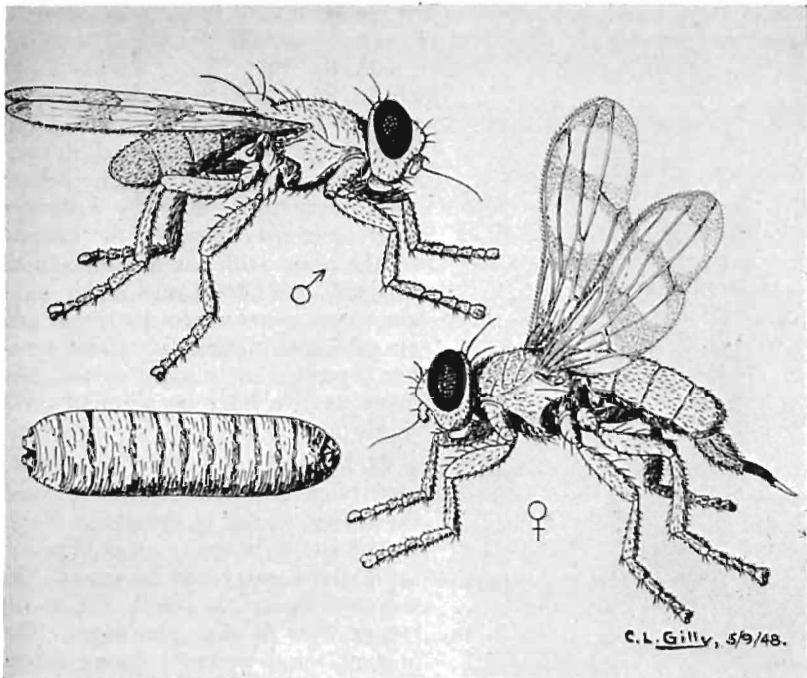


Fig. 1. The fly, male and female, causing the maize maggot disease of seedling corn. Also the pupa. This fly, *Euxesta major*, deposits its eggs near the ground level of the seedling. The larva makes its way through the whorl of leaves into the growing point of the plant. The larva feeds on the growing point and destroys it in part or in whole.

¹Project 974, Iowa Agricultural Experiment Station.

The ravages of this insect were first observed in the fall of 1945 when about 40 collections of Guatemalan corns were planted on the experimental grounds of the National School of Agriculture of Guatemala. Many of the plants were killed before they were 6 inches tall, and most of the rest were dwarfed and seriously malformed. The characteristic symptoms of those that were not killed immediately consisted of excessive stooling at the ground line, as a result of the partial destruction of a portion of the terminal growing point of the plant by the larva of the insect.

In 1946 a more detailed study was made of the malady and the causal relationship of the insect pest. Later in 1946 and in 1947 studies were made of the prevalence, distribution, host range and control of this insect on maize.

DETERMINATION OF THE INSECT PEST

Intensive studies in the field and laboratory revealed that the larva feeding in the growing point of the plant was the larval stage of the fly known as *Euxesta major* V. d. Wulp (Diptera, Otitidae). The adult is a small banded-wing fly common on maize soon after it emerges. (See fig. 1.) The female moves down the plant and over the ground around the plant, testing with the tip of her abdomen for cracks and crevices. At the time of placing eggs, she rests on the plant behind one of the basal leaf sheaths with the abdomen thrust backward and downward. In other instances the female may stand on the ground by the plant with the abdomen bent forward and downward. The eggs are white, slender and fusiform and are placed individually. The number deposited on a plant varies. As many as five have been found on a single plant.



Fig. 2. This is a longitudinal section of the corn plant showing the larva and injury to the growing point.

At hatching the young maggot penetrates the stalk moving toward the growing point of the young plant. If the plant is split longitudinally, the path of entry can be seen. The entrance tunnel is small, not much larger than a pin puncture. The maggot feeds on the growing point. (See fig. 2.) Seldom more than one maggot feeds on each plant. When full grown, the maggot is creamy white and measures about $1\frac{1}{2}$ centimeters in length and about $1\frac{1}{5}$ centi-



Fig. 3. (Left) An enlargement of the larva resting on tissue destroyed by feeding.

Fig. 4. (Right) An enlarged section of the living stem showing the pupa. The pupa has been moved away from the destroyed tissue over on the white healthy portion. The fly pupates in living and dead plants.

meter in diameter. At this time the maggot pupates in the dead tissues, or leaves the plant and pupates in the soil. The pupae are dark brown and about the same dimensions as the fully developed maggot. (See fig. 3.)

INJURY CAUSED BY THE MAIZE MAGGOT

The injury caused by the larva is largely incident to its feeding on the terminal growing point of the young corn plant. It does not feed on the roots, leaves or ear shoots. Generally the first symptom of maggot infestation is the flagging of the terminal leaf which is often wholly or partially severed by the feeding maggot. In a few days the terminal portion of the plant becomes dark brown and dries up. When the maggot reaches the growing point early in the seedling stage, the plant usually dies immediately. If, on the other hand, only a portion of the growing point is destroyed, the lateral buds on the growing point develop, forming a dwarfed, bushy plant. Often these branches or suckers die when very small; others, however, may become 1 to 4 feet tall, tassel and develop imperfect ear shoots. The dwarfed branches have short internodes causing the leaves to be closer together than

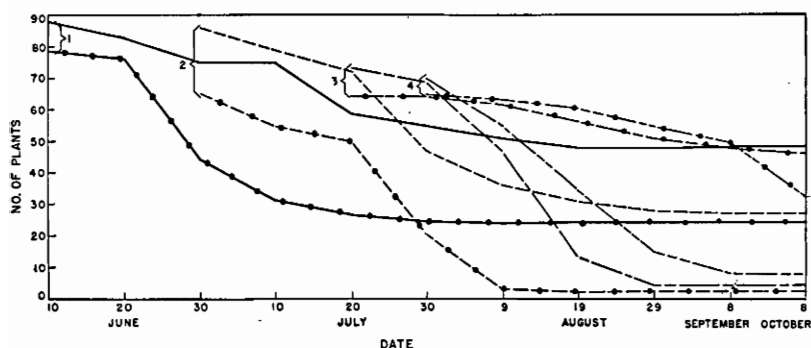


Fig. 5. The amount of maize maggot injury was ascertained for four different dates of planting on dusted and not dusted stands resulting from planting 100 kernels during June and July, 1948 at Antigua, Guatemala.

- 1 = Planting made June 1, first counts taken June 10.
- 2 = Planting made June 20, first counts taken June 30.
- 3 = Planting made July 10, first counts taken July 20.
- 4 = Planting made July 20, first counts taken July 30.

The major injury to the plants occurred in the first 30 days after the plants emerged. The plain and dotted lines indicate the number of plants killed or injured as the growing period advanced. Alternating rows were dusted with gamexsan weekly until the plants were 9 to 10 inches tall. In experiments 1 and 2 the dotted lines constitute the checks, and in 3 and 4 the order is reversed, the broken lines represent the checks and the dotted the dusted. In each of the four trials more than 60 percent of the plants were killed or injured. The major injury to the plants occurred within the first 30 days. The first planting suffered least. Dusting with gamexsan in each of the four trials reduced the maize maggot injury.

on the normal plant. (See fig. 4.) The extent of the injury is shown in fig. 5 on maize grown at Antigua in 1948. Plantings were made every 10 days beginning June 1 and extending to Oct. 1. Figure 5 shows the number of healthy plants on successive dates in four of the trials. The greatest amount of injury resulted during the first month after emergence in each of the four trials. Less injury occurred in the June 1 planting than in the other three. The survival in all four trials was low as shown in fig. 5.

The color of the attacked plants varies. The very young plants that are not killed outright often take on a dark green color, and in some cases this color is maintained throughout the development of the plant. In other cases it loses this dark green color becoming greenish yellow with white stripes. Where the terminal growing point is not attacked by the maggot until the plant is out of the seedling stage, 6 to 8 inches high, the lateral branches may be more normal in color and development. There may be only one branch or several depending upon the time and extent of the injury caused by the larva. (See figs. 6, 7 and 8.)

Often there is associated with the maggot injury a soft rot of the surrounding tissues which hastens the death of the young plant. In the disintegrated tissues, small larvae and pupae of other insects that may be parasites of the maize maggot are often found.

OTHER HOST PLANTS

The maggot attacks teosinte in the same manner as the maize plant. Although a search has been made for other hosts, maize and teo-

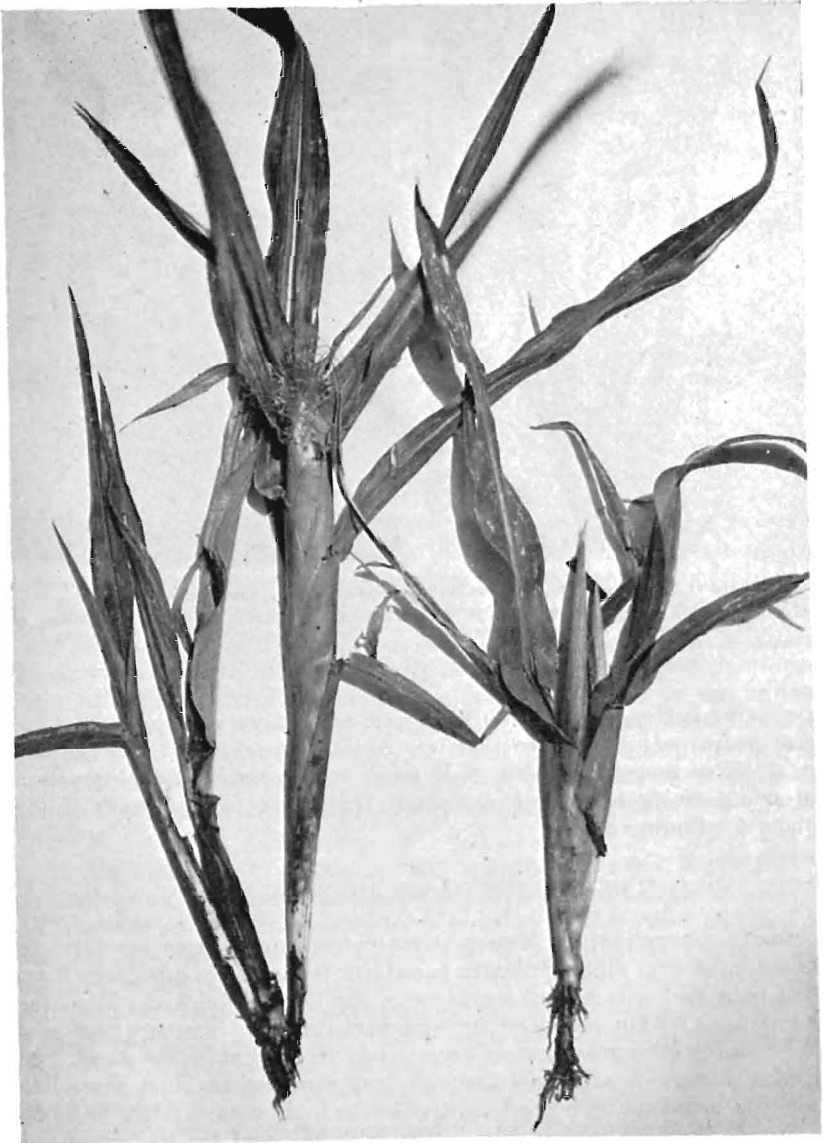


Fig. 6. Maize maggot injury on older corn plants showing a form of branching and flower formation.

sinte are the only ones that have been found to date. Five other members of the tribe Maydeae have been grown near or in corn plots for the past 2 years without being parasitized. These other maydeae are three species of *Tripsacum*, *Coix lachryma-jobi* L., and *Polytaca* spp. Thirteen varieties of sorghum, two varieties of broom corn, 29 va-



Fig. 7. (Left) Maize maggot injury. Note that the central branches are short and dying.



Fig. 8. (Right) Maize maggot injury in the field when the healthy plants were beginning to flower. In this case the maggot failed to destroy a portion of the growing point, permitting considerable growth in the injured plant.

ieties of barley, 37 varieties of wheat and 34 varieties of oats were also grown adjoining corn that was seriously parasitized without any evidence of maggot infestation. In addition the weedy grasses common in maize fields have been examined frequently for evidence of the maggot without success.

PREVALENCE AND DISTRIBUTION

Maize maggot injury is very prevalent on maize from sea level to about 6,000 feet altitude. Above 6,000 feet the maize is quite free from this pest, and it is not as prevalent in the low coastal areas as in the highlands. Within its range it is so prevalent and destructive that a heavy infestation may destroy from 25 to 98 percent of the stand. The Indian farmer has learned through long practice the best season to plant to avoid maize maggot injury. In the highlands at 4,000 to 6,000 feet this has been found to be in the late period of the dry season or at the very beginning of the wet season. In the lower altitudes where two crops are grown, the second crop is planted in late August and early September. Crops planted at these two periods usually show little injury. On the other hand, crops planted after the dates named very often are seriously injured. It must be that these planting dates have a direct relation to the life history of the fly, *Euxesta major*. The distribution noted above relates only to Guatemala. Evidence in the other Central American countries and Mexico is limited. However, it has been

established through surveys that the maize maggot occurs in El Salvador, Honduras and Costa Rica. In El Salvador maize maggot injury is known as empalmado del maiz by virtue of the palmlike development. The fact that the injury has acquired a common name indicates that this malady is of long standing. Felex Chussey, formerly director of research in El Salvador, said in conversation that he knew the disease in El Salvador and showed a picture of the symptoms. As additional surveys are made, it is quite probable that maize maggot injury will be found in Mexico and the maize growing countries of northern South America.

CONTROL OF THE MAIZE MAGGOT

The matter of controlling this insect pest becomes of great importance in connection with any program of mechanized maize production in Central America. The stand has a very direct relation to the yield. While the Indian farmer practicing hoe culture in his corn production program can and does replant, frequently several times, the farmer practicing mechanized production cannot do this without heavy extra cost. Still further, in order to derive the full benefit of the wet or favorable growing season for maize it is not possible always to plant when the maize maggot population will be low. The only alternative open to mechanized production is some form of control.

Considerable experimental evidence using wet and dry insecticides has been accumulated during the past 2 years. In 1946 such insecticides as lead arsenate, DDT and Ryania (a new insecticide developed by the Merck Chemical Company) as sprays and dusts on the ground and on the plants were tried in controlling plot experiments. Dusting proved more effective than spraying under the conditions that prevail at Antigua. However, none of these three products controlled the maize maggot adequately even when 10 applications were made at 4-day intervals.

In 1947 gamex (6 percent gamma isomer of benzene hexachloride in talc also known as gammexane) and Ryania (an improved product of Merck Chemical Company) were tested. A 10 percent gamex was worked into the top surface of the soil 24 hours before the seed was planted at the rate of 50 pounds per acre. The seed was treated with Arasan and Arasan plus 10 percent DDT before planting. The planting was made Aug. 17, 1947. The final count of healthy and maggot injured

TABLE 1. CONTROL OF MAIZE ROOT MAGGOT BY CHEMICAL TREATMENT OF SEEDS AND SOIL.

Soil treatment	Seed treatment	Plant population			
		Stand	Healthy	Maggot injured	Percent healthy
Gamex	Check	495	243	252	49.1
	Arasan	163	87	76	53.4
	Arasan and DDT	161	76	85	47.2
	DDT alone	156	76	80	48.7
No gamex	Arasan	170	29	141	17.06
	Arasan and DDT	163	24	139	14.7
	DDT alone	143	37	106	25.8
	Check	470	82	388	17.4

plants was made on Oct. 26, after a lapse of 70 days. The data obtained are shown in table 1.

The data indicate that the application of gamex reduced the maggot injury about 31 percent and that the seed treatment had little or no effect. It is significant that the gamex as applied had no effect on the germination and subsequent development of the seedlings. It did prove injurious in other experiments when placed near the seed down 2 inches in the soil. In three later experiments where these insecticides were tested further, the value of gamex when worked into the surface of the soil was less and at no time did the seed with Arasan and DDT show any significant decrease of the maggot injury. This might be expected since the fly does not live in or on the seed.

Another experiment involving a prepared gamex dust BHC-50 (6 percent gamma isomer, 44 percent other isomers and 50 percent inert material, by John Powell Co. of New York City), and 10 percent Ryania in water plus a soap sticker was started Aug. 24 on 2-week-old seedlings. Six hundred seventy-six and 525 plants, respectively, were sprayed three times, at weekly intervals with the two products named above. Only 12.7 percent and 11.6 percent were free from maggot injury after 30 days. The check plot not sprayed also had 12.7 percent healthy. Since spraying showed no promise, attention was turned to dusting and sodium nitrate dressings of the soil. On Oct. 24, a replicated experiment was started involving the use of sodium nitrate as a fertilizer (100 pounds per acre) in the row and two insecticides,

BHC-50 and Ryania. The dust was applied with a small dust gun and an attempt was made to apply only enough dust to effect good foliage coverage, estimated at 30 to 40 pounds per acre. The young plants were dusted five times at weekly intervals.

The number of plants that were healthy and maggot injured were counted the last time on Dec. 2 after 39 days. The data indicated that the sodium nitrate dressing reduced the maggot injury to some extent, probably by hastening the rate of growth of the seedling, thus shortening the period of susceptibility. The five applications of dust in



Fig. 9. This shows a portion of two rows, one dusted five times with gamex and the check row not dusted. In the dusted row 88.3 percent of the plants were healthy, and in the check row, 10.2 percent.

TABLE 2. CONTROL OF MAIZE ROOT MAGGOT BY CHEMICAL TREATMENTS OF SOIL.

Soil treatment	Dust	Plant population			
		Total plants	Healthy	Maggot injured	Percent healthy
NaNO ₃	Gamex in soil	291	68	223	23.5
NaNO ₃	Gamex on plants	266	235	31	88.3
NaNO ₃	Check	285	29	256	10.2
NaNO ₃	Ryania in soil	251	87	164	34.6
NaNO ₃	Ryania on plants	315	138	177	43.8

each case reduced the amount of maggot injury but the BHC-50 was much superior to the Ryania. This experiment and others comprising the use of BHC-50 indicate that maggot injury can be markedly reduced with this insecticide. (See figs. 5 and 9.) However, the strengths, time and most practical methods of application need to be worked out.

Una Nueva Plaga Del Maíz En La América Central

RESUMEN

POR I. E. MELHUS Y HALBERT M. HARRIS

DIRECTOR, IOWA STATE COLLEGE-GUATEMALA TROPICAL RESEARCH CENTER
HEAD, DEPARTMENT OF ZOOLOGY AND ENTOMOLOGY, IOWA STATE COLLEGE

Existe en varias partes de la América Central, una devastadora plaga del maíz la cual consiste en el daño causado por la larva de una mosca conocida con el nombre de *Euxesta major* v. d. Wulp (Diptera, Otitidae). Esta plaga aunque bien conocida en las regiones donde ocurre, es desconocida para la ciencia. Fué primero observada por los autores en 1945 en los campos experimentales de la Escuela Nacional de Agricultura de Guatemala. Aquí, la mayoría de las plantas en 40 colecciones de maíz, sembradas, fueron destruidas, argeniadas o contrahechas a consecuencia de esta enfermedad. Un síntoma característico de las plantas afectadas era el de la producción excesiva de hijos.

La Mosca pone sus huevos individualmente en las hendeduras o heridas, en las vainas de las hojas inferiores de la planta. Los huevos son blancos, delgados y fusiformes. De ellos surge la larva, la cual se alimenta en el meristemo terminal de la planta joven. La larva es blanca y mide 1.5 cm de largo por 2 mm de grueso en estado de completo desarrollo. La pupa es de color pardo, y vive en el tejido enfermo o en la tierra.

A consecuencia de los daños causados por esta larva se pueden perder del 25 al 98% de las plantas sembradas. Los mayores daños ocurren durante el primer mes después de la germinación de la semilla. Generalmente se puede observar conjuntamente con esta larva, una podredumbre blanda de los tejidos adyacentes, además de larvas de otros insectos que pueden ser parásitos de la que nos ocupa. Los únicos hospederos de esta plaga conocidos hasta la fecha son el maíz y el teosinte.

El agricultor nativo ha aprendido ya, cuál es la mejor época de siembra, para evadir los daños causados por esta plaga. En tierra fría, en Guatemala (1200 a 1800 metros) esta época es la comprendida entre el fin de la estación seca y el justo principio de la estación lluviosa.

De todos los insecticidas que se han probado para combatir esta plaga, a saber: Ryania, Arseniato de Plomo, D.D.T., B H C-50; solo el último, B H C-50 (6% Gamma isómero de Hexacloruro de Benceno, en talco) dió resultados prometedores al aplicarse en forma de polvo sobre las plantas pequeñas.

An Interesting Guatemalan Chilli (*Capsicum Guatemalense* Bitt.)

BY A. T. ERWIN

IOWA AGRICULTURAL EXPERIMENT STATION¹

On a recent trip to Guatemala, our attention was drawn to a black-seeded pepper, native to this region. The following discussion covers observations made of this plant in its native habitat and as grown at Ames.

The use of the peppers in Latin America, as a condiment and for various other purposes, reaches back into the period of unrecorded history. They are credited with many virtues. The juice is claimed to be a sure cure for toothache, ague, fever and digestive disturbances. Sofford (6) reports recovering dried pods of cayenne pepper, *Capsicum frutescens*, from the prehistoric tombs of Anacon, Peru. Our first record of peppers was made by Peter Martyr (5) who accompanied Columbus on his first voyage to the new world. He found numerous kinds of "ages (peppers), one kind as long as the length of a man's fingure, the other is round—they have a hotte kinde of sharpness and biting." Chanca (4), Columbus' physician, likewise records this plant and is credited with its introduction to the old world.

The pungency of peppers is due to the volatile alkaloid, capsaicin, and varies widely among different species and varieties. The percentage of capsaicin was not determined for this species, but it apparently ranks high in this regard for the Indians regard it as one "el mas picante de los picantes," the hottest of the hot.

DESCRIPTION OF *CAPSICUM GUATEMALENSE*

This black-seeded pepper is a semi-shrubby plant attaining a height of 10 to 12 feet. The branches are formed at right angles to the main stem, giving the plant its characteristic spreading habit of growth. The younger stems are angular, pubescent, with purplish nodes. (See fig. 3.) Leaves are oblique ovate to ovate lanceolate, apex incurved, base oblique, round to acuminate, entire upper and lower surface

¹Journal Paper J-1649 of the Iowa Agricultural Experiment Station, Project 316.



Fig. 1. (Left) The solitary flowers are purple with white at base of the petals.

Fig. 2. (Right) A branch of *Capsicum eggersii* showing the fruit. The pods are either a deep red or yellow.

densely pubescent on young plants, but less pronounced on the surface between the veins of the leaves of older plants. (See fig. 1.)

Flowers are solitary axillary, rather sparse, campanulate, rotate. Petals are purple, white and united at base with involute margins. Other characteristics are calyx pateriform, sepals subulate; anthers linear, two celled, dehiscense longitudinal; peduncle, about 1 inch, pendant; pods somewhat conical, 1 to 1½ inches in length, color red or yellow. (See fig. 2.)

Bitter (1 and 2) previously described another plant closely related to the one under consideration, as *Capsicum eggersii*. Bitter delineates between *C. eggersii* and *C. guatemalense* on the basis that the latter bears wider, coarser leaves, more abundant flowers with shorter pedicels and longer anthers. However, we regard the differences he names as minor in character. Plants grown at Ames on thin clay and on a fertile loam show these minor variations, also the older plants are much more floriferous than the young ones. Bukosov (3) described a similar plant which he designated *C. pubescens*. The latter term is a very appropriate one for the plant under consideration. He characterizes *C. pubescens* as having larger fruit and thicker leaves than *eggersii* and *C. guatemalense*. In the absence of the type specimens, final judgment is reserved. However, we are inclined to question the existence of three different species of this pubescent type and to class *C. guatemalense* and *C. pubescens* as varieties of *C. eggersii*. If quantitative rather than



Fig. 3. The young branches are characterized by a dense pubescence.

qualitative characters are to be accepted as the criteria for a species, then surely in the apple family we would have *Pyrus grimesii*, *jonathanii* and a hundred other species instead of one species, *Pyrus malus*, as commonly accepted. *Capsicum guatemalense* was collected at an elevation varying from 5,000 to 6,000 feet in Guatemala. The plant appears to have a considerable range. Bukasov (3) reports having collected *C. pubescens*, which appears to be merely a botanical variety of the same plant, in Colombia.

Plants grown in Ames which were started

in the greenhouse flowered and set seed rather late in the summer indicating that it required a long season in which to mature a crop. As a perennial, it obviously would not withstand the northern winters.

Dwarf early maturing strains of *C. frutescens* have provided us with our present day garden varieties of peppers. Similarly, early strains of *C. guatemalense* could possibly be developed. A more promising field, however, might be that of crossing this plant with our garden varieties, as it appears to be free of certain pathogens affecting *C. frutescens*.

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²The author is indebted to I. E. Melhus and Robert Nichols for supplying additional seed stocks and habitat data.

Una Variedad De Chile En Guatemala (*Capsicum eggersii* Bitt.)

RESUMEN

POR A. T. ERWIN

IOWA AGRICULTURAL EXPERIMENT STATION

En un viaje a Guatemala llamó la atención del autor, la existencia de un chile de semilla negra, muy común en la región.

El uso del chile en la América Latina como condimento y para otros usos data de tiempo inmemorial, atribuyéndosele varias propiedades medicinales entre otras el alivio del dolor de muelas, calentura y trastornos digestivos.

El sabor picante del chile es debido a un alcaloide Llamado Capsaicina. El porcentaje de Capsaicina en este chile no se ha determinado pero se considera alto puesto que los indígenas lo tienen como "El más picante de los picantes."

DESCRIPCION DEL *CAPSICUM EGGERSII* BITT.

Arbusto perenne de 3 a 3.5 metros de altura, con brotes angulares, pubescentes, y nudos violados. Hojas ovaladas, base oblicua, pubescentes. Flores solitarias, acampanadas, de color blanco o violado; anteras cilíndricas, dehiscencia longitudinal. Frutos cónicos de 2.5 a 4 centímetros de largo, rojos o amarillos. Esta planta crece en las regiones comprendidas entre 1500 y 1800 metros de altura sobre el nivel del mar.

Helminthosporium turcicum Leaf Blight of Maize in Guatemala¹

BY I. E. MELHUS, GEORGE SEMENIUK AND EDGAR F. VESTAL

IOWA STATE COLLEGE-GUATEMALA TROPICAL RESEARCH CENTER

Diseases of corn in Guatemala are destructive and little known. Although Guatemala is only nine-tenths the size of Iowa, its tropical location and mountainous terrain makes possible the existence of greater climatic variations, with consequent effects on the prevalence and destructiveness of certain plant parasites. There are in most sections, two seasons, the wet and the dry with variations of 15 to 200 inches of rain between different regions, and temperature differences occasioned by altitudes from sea level to more than 10,000 feet. The climates brought about by these variations in season, rainfall and altitude provide conditions in some regions that permit the development of most parasites that are known to corn.

¹Project 878 Iowa Agricultural Experiment Station.

Probably the most destructive disease of maize, especially in the highlands of Guatemala at 4,000 to 6,000 feet elevations, is a leaf blight caused by *Helminthosporium turcicum*. It is very prevalent and destructive on corn in many parts of Guatemala. The leaf blight was first encountered by us in 1945 in the San Antonio Huista and Jacaltenango regions of the Cuchumatanes mountains in the department of Huehuetenango. The foliage of mid-season corn was killed in September when the ears were in the late dough stage. The long-season, highland corn showed less infection.

The following year we found *Helminthosporium* leaf blight to be very destructive in the Coban region of Alta Verapaz. It was estimated that the September yield of corn was damaged from 5 to 20 percent. This is a region where the rainfall is high, often more than 100 inches. In 1946 in our own experimental plots on the grounds of the Guatemalan National School of Agriculture near Guatemala City, where the rainfall averages about 50 inches per year, blight was general on 200 corn collections in trial. In similar experimental plots on the banana growing plantation near Tiquisate on the low Pacific coastal area (altitude 150 feet, rainfall about 80 inches) and near the city of Quetzaltenango (altitude 8,735 feet, rainfall about 100 inches) in a mountain temperate climate, there was a little leaf blight. Also near Antigua (altitude 4,953 feet and about 40 inches rainfall) there was very little leaf blight.

LEAF BLIGHT IN 1946 IN THREE DIFFERENT CLIMATIC SITES

Helminthosporium leaf blight development was observed during 1946 on 46 different Guatemalan corn collections grown in three climatic sites. These were near the cities of Coban and Antigua and at the National School of Agriculture. Coban is situated on the north slope of the mountain range that extends across Guatemala from east to west. This city has an altitude of 4,200 feet and rainfall of about 120 inches per year. The rain falls mostly in 8 to 9 months of the year. The climate is temperate and humid. The National School of Agriculture lies on the south slope of the mountain range at about 4,855 feet altitude. The rainfall is seasonal, about 50 inches, mostly limited to the 6 months between June and November. The climate is temperate and moderately humid. Antigua is situated on the same slope as the National School of Agriculture in an adjoining valley at 4,953 feet elevation, and has a lower rainfall than either Coban or the National School of Agriculture. The rainfall is generally 35 to 40 inches per year, and the climate is humid during the 6-month rainy season.

The corn collections were planted in replicated plots of 20 hills each at Coban in April, at the National School of Agriculture in early June and at Antigua in March. The plots were read twice for leaf blight during the growing season, first when the plants were shedding pollen and again when the ears were in the late dough stage. The higher of the two readings is represented in table 1.

The table shows the estimated amount of leaf blight on the 46 collec-

TABLE 1. *HELMINTHOSPORIUM TURCICUM* LEAF BLIGHT DEVELOPMENT ON FOUR GROUPS OF GUATEMALAN CORNS IN THREE DIFFERENT CLIMATIC SITES IN GUATEMALA, 1946.

Group	Corn collection no.	Foliage-necrosis* at			Group	Corn collection no.	Foliage-necrosis* at		
		Coban	Finca Barcena	Antigua			Coban	Finca Barcena	Antigua
Mountain	1A-46	1	2	Tr	Coast	21A-46	4	1	Tr
	2A-46	1	2	Tr		46A-46	3	3	Tr
	33A-46	3	1	0		23A-46	4	3	1
	39A-46	4	1	Tr		13A-46	3	1	1
	40A-46	2	2	Tr		41A-46	4	3	Tr
	27A-46	1	1	Tr		9A-46	4	1	1
	3A-46	1	Tr	Tr		11A-46	2	2	Tr
						34A-46	3	1	Tr
Highland	22A-46	1	4	Tr	Early dwarf	35A-46	2	1	Tr
	25A-46	1	1	Tr		36A-46	3	2	Tr
	28A-46	1	1	Tr		38A-46	3	2	Tr
	29A-46	1	Tr	Tr		43A-46	4	4	0
	102A-46	—	1	—		10A-46	3	2	Tr
	19A-46	2	1	Tr		12A-46	2	1	Tr
	8A-46	1	1	1		42A-46	4	1	Tr
	4A-46	1	Tr	Tr		44A-46	3	1	—
	14A-46	1	1	Tr		45A-46	1	1	—
	15A-46	3	Tr	Tr					
	16A-46	1	Tr	Tr		30A-46	5	1	Tr
	17A-46	1	1	Tr		31A-46	4	1	0
	20A-46	3	1	Tr		32A-46	2	2	0
	47A-46	Tr	Tr	0		24A-46	4	3	Tr
	49A-46	1	1	Tr		26A-46	3	1	Tr
	99A-46	—	1	—					
	119A-46	—	1	—					

*Scale of foliage necrosis:

- 0 = no lesions.
- Tr = less than 1 percent leaf area destroyed.
- 1 = 1 to 5 percent leaf area destroyed.
- 2 = 6 to 25 percent leaf area destroyed.
- 3 = 26 to 50 percent leaf area destroyed.
- 4 = 51 to 75 percent leaf area destroyed.
- 5 = 76 to 90 percent leaf area destroyed.

This scale is devised to indicate clearly those collections that show resistance and high susceptibility.

tions of Guatemalan corn, arranged according to phytographic groups, in the three climatic sites. The amount of leaf area destroyed was graded on an arbitrary scale from one to five. There was wide variation in the amount of leaf blight in the three different climatic sites. The injury was most severe at Coban and least at Antigua. The rainfall at Antigua was 12.28 inches which was less than the average of 35.28 inches for the period 1933 to 1946, inclusive. The significant fact brought out by the data was the smaller amount of leaf blight development on the highland corns in the three climatic sites. The indications were that this corn group was more resistant than the other three. One highland corn collection identified by our number as 47A-46 (fig. 1) showed only a trace of leaf blight at Coban and at the National School of Agriculture. This corn seemed to carry more resistance to this disease than any of the other corns in the same group.

LEAF BLIGHT IN THREE DIFFERENT CLIMATIC SITES IN 1947

In 1947, 93 Guatemalan corn collections were grown in the same three climatic sites as in 1946. Most of the corn collections were different from those of the previous year, falling mostly in the coast and highland groups. There were only three collections each of the mountain and early dwarf groups.

The rainfall at Antigua was higher in 1947 than in 1946 and there was more leaf blight. The leaf blight damage was severe at the National School of Agriculture and Coban, especially on coast corns. Highland corns were generally resistant.

The response of 81 collections planted at Coban may serve to show the extent of leaf blight development and the comparative injury to two groups of corn. The 81 collections were planted in three randomized blocks in April and harvested in late August. Thirty hills of each were planted in two rows, $3\frac{1}{2}$ feet apart, and the hills 21 inches apart

in the row. Two kernels were planted in each hill. This close planting was followed to make conditions as favorable as possible for the leaf blight pathogen. The land had been in corn the 2 previous years and probably had grown many corn crops in the past 1,000 years.

The outstanding result, as may be seen from table 2, was that only five collections showed little leaf blight. Two of these were originally collected near Coban. The other three were from other parts of Guatemala. All five of the leaf blight resistant collections of the 81 in trial were among the 15 high yielding corns. (See table 3.)

LEAF BLIGHT AT ANTIGUA AND NATIONAL SCHOOL OF AGRICULTURE IN 1948

In 1948, leaf blight data were obtained on U.S. inbreds, U.S. single crosses, Guatemalan corns



Fig. 1. A plant of 47A-46 growing at Antigua in 1948. It is a highland corn collected in Coban. During 1946, 1947 and 1948 this collection showed strong resistance to *Helminthosporium* leaf blight in three different climatic sites in Guatemala, and in plot trials at Ames in 1948.

TABLE 2. LEAF AREA DESTROYED BY *HELMINTHOSPORIUM TURCICUM* ON 93 ENTRIES IN THREE DIFFERENT CLIMATIC SITES IN GUATEMALA, 1947.

Group	Collection no.	Foliage necrosis at:			Group	Collection no.	Foliage necrosis at:		
		Finca Barcena	Coban	Antigua			Finca Barcena	Coban	Antigua
Mountain	22A-46	2	Tr	Tr		134A-46	Tr	3	2
	74 -44	3	4	1		92 -44	3	5	2
	22 -47	2	—	1		308A-46	2	2	2
Highland	4A-46	1	Tr	Tr		326A-46	2	3	1
	70#	1	Tr	Tr		328A-46	3	1	1
	29 -44	3	3	1		329A-46	2	2	1
	95A-46	5	2	1		338A-46	4	4	1
	99A-46	Tr	1	Tr		332A-46	3	—	2
	119A-46	1	2	1		333A-46	4	5	1
	159 -44	0	0	Tr		335A-46	4	4	2
	331A-46	4	3	2		336A-46	Tr	2	2
	400A-46	1	—	—		401A-46	Tr	—	—
	339A-46	0	Tr	0		338A-46	1	1	2
	432A-46	1	—	1		340A-46	3	3	2
	343A-46	1	1	—		341A-46	4	4	2
	344A-46	Tr	3	1		370A-46	1	4	2
	346A-46	—	2	1		393A-46	3	4	2
	348A-46	1	3	Tr		394A-46	2	3	2
	84 -44	1	4	1		395A-46	4	5	2
	40 -44	1	3	2		319A-46	4	—	—
	33 -44	2	1	2		91 -44	3	4	1
	1757 -45	4	—	1		86 -44	4	3	2
	28 -44	2	3	2		77 -44	3	4	2
	20 -47	Tr	—	Tr		76 -44	3	—	1
	23 -47	Tr	—	Tr		68#	3	—	—
	10 -47	Tr	—	0		64 -44	4	—	2
	12 -47	Tr	—	0		26 -44	2	4	2
	14 -47	1	—	1		15 -44	3	5	2
	7 -47	2	—	1		9 -44	2	1	1
	6 -47	Tr	—	Tr		179A-46	2	—	—
	1660 -45	2	—	1		1652 -45	2	—	1
	1466 -45	2	—	2		609 -45	3	—	1
Coast	337#	2	2	1	Early dwarf	1626 -45	2	—	2
	7A-46	3	2	2		1449 -45	2	—	—
	10A-46	1	1	Tr		1448 -45	1	—	2
	11A-46	2	2	1					
	12A-46	2	1	2		30A-46	4	3	1
	13A-46	2	3	Tr		368A-46	1	3	1
	283#	1	1	1		392A-46	2	—	2
	198 -44b	4	5	1		369A-46	2	—	3
	36A-46	4	3	2					
	38A-46	4	4	1					
	41A-46	4	—	2					
	198 -44a	3	5	1					
	45A-46	1	3	1					
	46A-46	4	3	2					
	167 -44#	4	4	1					
	96A-46	1	4	2					
	101A-46	1	2	1					
	105A-46	3	2	—					
	118A-46	3	4	2					
	121A-46	2	5	2					
	122A-46	2	4	2					
	125A-46	4	4	2					

and hybrids between Guatemalan corns and 10 U.S. inbreds and one U.S. single cross. The U.S. inbreds and single crosses were planted in two replications of 30 hills each. The Guatemalan corn and the hybrids between Guatemalan and U. S. corn were each planted in three replicated plots of 20 hills each. The plantings were all made in adjoining areas between April 4 and 18. Leaf blight readings were taken when the plants were in flower and again when the ears were in the hard dough stage of maturity in accordance with the scale previously indicated.

In fig. 2A is shown the amount of foliage necrosis in the U.S. inbreds

TABLE 3. LEAF BLIGHT REACTION OF 15 HIGH YIELDING CORN COLLECTIONS AT COBAN.

Corn collections	Group	Stand	Leaf number	Helminthosporium	No. ears	grain Quality	Bus.* acre
10A-46	coast	125	18.6	1.0	105	good	61
12A-46	"	69	20.8	1.0	58	"	66
13A-46	"	74	18.6	3.0	68	fair	51
96A-46	"	97	18.2	4.0	83	"	53
122A-46	highland	68	18.4	4.0	65	"	57.4
95A-46	"	61	20.2	2.0	59	good	51
327A-46	"	68	20.2	4.0	73	"	52.25
339A-46	"	112	19.4	Tr.	101	"	54
348A-46	"	114	19.2	3.0	114	"	51.7
342A-46	"	61	—	—	53	"	54.4
338A-46	"	102	18.0	1.0	76	"	50.0
345A-46	"	125	19.0	Tr.	102	"	49.0
20-44	"	30	21	Tr.	26	fair	37.25
70#	"	48	20.8	Tr.	35	good	47.3
159-44	"	40	19.2	0.0	26	fair	28.4

*Computed on basis of perfect stand.

and single crosses. All 13 of the inbreds were seriously injured. Inbred M14 showed the least injury and Oh, O7, Tr, R4, W22, Hy and I205 the most. Three of the single crosses, M14xOs 420, WF9 x Hy, and R4 x Hy, were as susceptible as most of the inbreds. The other six, 187-2 x L317, WF9 x M14, Os420 and L289 x I205, were less susceptible. (See fig. 2A.) As a group the U. S. inbreds and single crosses were more susceptible than any of the other corns. These results were in accordance with similar observations made during 1946 and 1947. Little or no grain developed on any of the inbreds. The U.S. single crosses matured some grain, but their reproductive stage was markedly underdeveloped. The response of the U.S. corns indicated clearly that conditions for the development of the leaf blight pathogen were highly favorable on the plots, with all the factors necessary to show their susceptibility or resistance.

In an adjoining area, 100 different Guatemalan corn collections were planted in a triple lattice design. Twenty-seven of these showed a reading of 1, 41 of 2, 17 of 3, and 5 of 4. (See fig. 2B.) The Guatemalan corns showed less leaf blight as a whole than the U.S. inbreds and single crosses. This was notably true of highland corns and less so of the coast, early dwarf and mountain corns. This further confirmed the records taken in 1946 and 1947 already discussed.

In another experiment comprising 45 crosses between Guatemalan corns and the single cross WF9 x 38-11, the amount of leaf blight ranged from 1 to 4 with 17 collections showing 2 or less. Only six were more susceptible than the single cross WF9 x 38-11. See the distribution

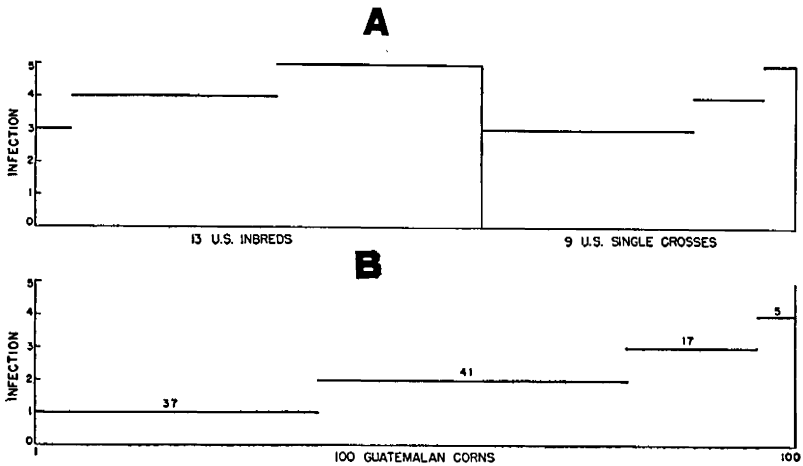


Fig. 2. A. The *Helminthosporium* leaf blight reaction of 13 U.S. inbreds and 9 U.S. single crosses grown at Antigua, 1948.

B. The *Helminthosporium* leaf blight reaction of 100 Guatemalan corns grown adjoining the U.S. corns.

Note that the U.S. corns in A were very susceptible and the Guatemalan corns were generally more resistant.

of the different corns in fig. 3A. In the same five randomized blocks were 16 of the Guatemalan corns used as checks. Figure 3B shows also their range of disease reaction. Note that there was less blight than on the hybrids.

Also near to the plots of U.S. inbreds and single crosses were plant-

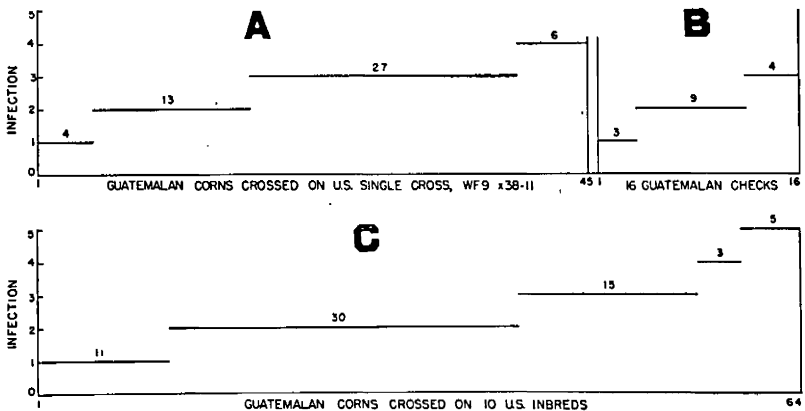


Fig. 3. These graphs show the leaf blight reaction of 114 top crosses and 16 open-pollinated Guatemalan corns.

A. The distribution of the leaf blight reaction of 45 Guatemalan corns crossed on U.S. single cross WF9x38-11.

B. The degree of injury on 16 open-pollinated Guatemalan corns used in making some of the hybrids (Guatemalan corns x WF9x38-11) in A.

C. The distribution of leaf blight reaction on 64 top crosses (Guatemalan on U.S. inbreds). The amount of leaf blight necrosis was higher than on the open-pollinated Guatemalan corns.

ed three replications of 64 hybrids between different Guatemalan corns and 10 U.S. inbreds. As shown in fig. 3C, 11 of these hybrids showed foliage necrosis of 1, 30 of 2, 15 of 3, 3 of 4 and 5 of 5. Indications were that the hybrids were intermediate in resistance to *Helminthosporium* leaf blight.

In still another experiment, there were five replications of 45 hybrids between different Guatemalan corns and the U.S. single cross WF9 x 38-11. The U.S. single cross was very susceptible as has already been noted. The amount of foliage necrosis of the other corns in this trial is shown in fig. 3A and B. The data again indicate that the hybrids between Guatemalan corns and the U.S. single cross WF9 x 38-11 were intermediate in resistance to leaf blight.

A summary of the results for 1948 are shown in table 4.

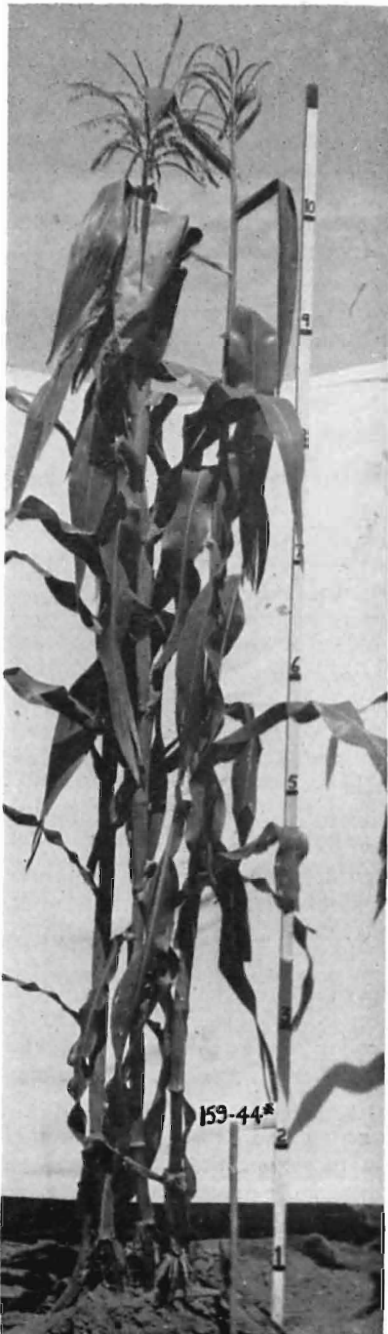
TABLE 4. RELATIVE FREQUENCY DISTRIBUTION OF CORN COLLECTIONS FALLING INTO DIFFERENT DISEASE SEVERITY CLASSES.

Sources of corn	Total no. of collections	Percentage of corn collections falling into injury classes				
		1	2	3	4	5
Guatemalan	100	37	41	17	5	0
Guatemalan	16	18	56	25	0	0
Guat. x U.S. inbreds	64	17	46	24	4.6	7.8
Guat. x (WF9 x 38-11)	45	11	28	48	13	0
U.S. inbreds	13	0	0	7	48	46
U.S. single crosses	9	0	0	66	22	11

Thus, more than three-fourths of the Guatemalan corn collections fell into injury classes 1 and 2 and none of these fell into 5. The U.S. inbreds and single crosses fell into injury classes 3, 4 and 5 with none in classes 1 and 2. The hybrids between Guatemalan corns and U.S. inbreds and the U.S. single cross WF9 x 38-11 were intermediate between these but leaning toward the resistant side. Thus with proper selection of Guatemalan corn, hybrids may be produced between it and the U. S. corns that have fairly high resistance to *Helminthosporium turcicum* leaf blight.

DISCUSSION

The field studies of *Helminthosporium turcicum* leaf blight on corn during 1946, 1947 and 1948 in Guatemala bring out the destructive nature of this pathogen to the crop within certain climates. For example, there was little leaf blight in the low altitude climate at Tiquisate (150 ft. elevation) or in the mountain climate at Quetzaltenango (8,735 ft. elevation). The altitude climates ranging from 3,000 to 6,000 feet seemed to be most favorable for the growth and development of *Helminthosporium turcicum*. Within the climatic zone where the leaf blight pathogen flourishes, it became most destructive where the rainfall was greatest during the growing season. For example, in Antigua in 1946, the rainfall was low, only 23 inches for the year.



There was little leaf blight during that year although Antigua is within the climatic region favorable to the leaf blight pathogen. In 1948, almost the reverse condition prevailed. The rainfall was high, 33 inches for the first nine months of the year from January to September, inclusive. Leaf blight was prevalent and destructive. The Coban area always receives more rainfall than either Antigua or the National School of Agriculture, and the amount of leaf blight in Coban is always higher than in the other two sites. Thus, given the rainfall and temperature, it may be possible to predict the amount of *Helminthosporium turcicum* leaf blight that may develop on corn in any part of Central America and in the United States.

Another fact that seems to be emerging from the numerous trials in the different climate sites is that the highland corns as a group are more resistant than the mountain, coast or early dwarf corns. However, not all the highland corns are resistant. Some appear to be quite susceptible but within this group there are many variants that show high resistance. It can be safely said that the highland group constitutes a pool of variants carrying much resistance to *Helminthosporium turcicum* leaf blight. The coast and early dwarf corns as a group were susceptible. Many of them appear as susceptible as the U.S. corns while others appeared somewhat more resistant.

The U.S. inbreds and single crosses in trial proved very susceptible. Susceptibility of the U.S.

Fig. 4. A highland corn that has shown high leaf blight resistance. It was collected in 1944 in a field near Chichicastenango at an altitude of 6,000 feet.

corns was in line with their known reaction in greenhouse and field trials in 1947 and 1948 at Ames, Iowa. The inbred NC34 reported as resistant by Elliott and Jenkins² was more resistant in the 1948 Guatemalan trials than any of the U.S. corns. This response of U.S. corns to *Helminthosporium turcicum* in Guatemala indicated the absence of strain differences in Iowa and Guatemala.

Isolates of *Helminthosporium turcicum* from Guatemala as well as the United States appear alike morphologically. Too, Guatemalan corns in field tests at Ames, Iowa in 1948 proved more resistant than the U.S. single crosses confirming the results obtained in Guatemala.

Six of the most resistant corns that have been found during the past 3 years are highland corns. Two of these are shown in figs. 1 and 4. They are now being subjected to intensive study and purification.

La Enfermedad De Estrías En Guatemala, *Helminthosporium turcicum*

RESUMEN

POR I. E. MELHUS, GEORGE SEMENIUK Y EDGAR F. VESTAL
IOWA STATE COLLEGE-GUATEMALA TROPICAL RESEARCH CENTER

Las enfermedades del maíz en Guatemala son poco conocidas a pesar de que causan serios daños a las cosechas. La posición tropical de Guatemala y su terreno montañoso, determinan la existencia de marcadas diferencias climáticas, las cuales permiten el desarrollo de toda clase de agentes patógenos que atacan al maíz.

Helminthosporium turcicum, fué primero encontrado por los autores en la región de San Antonio Huista y Jacaltenango en el Depto. de Huehuetenango en 1945; y mas tarde en el mismo año en la región de Cobán, Alta Verapaz donde era predominante en los campos de maíz. La precipitación pluvial en esta región es de 3,000 mm. anuales en promedio.

En 1946 en nuestras parcelas experimentales en la Escuela Nacional de Agricultura de Guatemala, pudimos observar que 200 de nuestros tipos de maíz aparecían atacados por esta enfermedad. En cambio, en Tiquisate, Antigua y Quezaltenango, encontramos muy pocos daños.

Nuestros estudios sobre esta "Enfermedad de Estrías," causada en el maíz por el hongo *Helminthosporium turcicum*, llevados a cabo en 1946-1947 y 1948, indican que la enfermedad es destructora dentro de ciertos límites climáticos. Las regiones situadas entre 1,000 y 1,800 m. de altura parecen ser las más favorables para el desarrollo del hongo; y mas aún, que dentro de estos límites los daños son mas serios en los lugares de mayor precipitación pluvial. Hemos observado además,

²*Helminthosporium turcicum* Leaf Spot of Corn. Phytopathology 36:660. 1946.

que los maíces de tierra fría en conjunto, son mas resistentes al *Helminthosporium turcicum*, que los de costa, de montaña, o tempranos. Sin embargo no todos los maíces de tierra fría son resistentes y, por supuesto, puede encontrarse resistencia en cualquiera de los otros grupos. Las líneas puras e híbridos de E.E.U.U. resultaron ser muy susceptibles a la enfermedad. El organismo encontrado en Guatemala, es morfológicamente igual al de los Estados Unidos. Los maíces Guatemaltecos, mostraron mayor resistencia a la enfermedad que los norteamericanos, en Ames, Iowa, en 1948.

Seis de los maíces mas resistentes, aislados hasta la fecha, son de tierra fría, éstos son, en nuestra clave numérica: 70; 20-44; 159-44; 47A-46; 339A-46; y 345A-46.

A Preliminary Study of the Growth Response in Iowa of Hybrids Between Guatemalan and United States Corn¹

BY I. E. MELHUS, GEORGE SEMENIUK AND J. R. WALLIN

IOWA STATE COLLEGE-GUATEMALA TROPICAL RESEARCH CENTER

The wide variation and diversity of forms that exist in tropical corns has been well established through the excellent work of Sturtevant (7), Collins (2), Weatherwax (9), Kempton (4), Kuleshov (5), Vavilov (8), Mangelsdorf and Reeves (6), Anderson and Cutler (1) and Cutler (3). Little has been done to explore the potentialities of this pool of germ plasm. This may be due to two causes: first, that such corns when transplanted to the United States do not complete their full life cycle, as they do in their native habitats; and second, that few students have had an opportunity to follow the growth and development of these corns in their native tropical climates. The sensitivity of the Guatemalan corns was indicated in 1945 and 1946 when Guatemalan corns were planted at normal periods in Arizona, Colorado, Kansas, South Dakota, Iowa and Weslaco, Texas, involving latitude differences of 29 degrees and altitude differences of 8,000 feet. Except at Weslaco, Texas, nearly all the plants at the different stations failed to reach tasseling stage before frost despite extensive vegetative development. The growing season needs of the Guatemalan corns in these cases were even greater than that provided by the climates of these locations. At Weslaco, Texas, the majority of the collections tasseled and matured some seed but the response of the plants was not comparable to that in the tropics. Plainly, most of the tropical corns could not be moved, as such, into the climate of the corn belt and their germ plasm studied effectively. The only recourse was to study and evaluate the corns in their native habitat in the tropics and to transmit their desirable germ plasm to the corn belt in hybrid combination with corn belt corns.

¹Project 974 of the Iowa Agricultural Experiment Station.

The attempted introduction of Guatemalan corn germ plasm into the corn belt brought many unknowns that required exposition. For example, it was not known how readily the Guatemalan corns, which are very unlike U.S. corns, would combine with our inbreds and if they did cross freely, what characters of the Guatemalan corns and the U.S. inbreds would be retained or lost in the hybrid. Our own experiences and those of others had shown that the climatic adaption of the Guatemalan corns was so distinctly different from that of the corns of the corn belt that there was a question whether the hybrids could be brought into approximately the same maturity period as our U.S. corns. Unless this could be done, the production of abundant seed stocks on a field basis would become difficult and would constitute a stumbling block to transplanting characters of the corns of the tropics into those of the corn belt. These and many other questions needed to be answered and a procedure developed. Unless this could be done readily and effectively, it would not be possible to utilize the desirable characters that might be found in the Guatemalan corns in breeding programs in the corn belt.

TRIALS AT SHENANDOAH IN 1946

Fifty-six experimental hybrids were made in Weslaco, Texas, in the spring of 1945 before the Iowa State College-Guatemala Tropical Research Center was organized in Guatemala. Individual plants of Guatemalan open-pollinated corn were crossed with 12 United States inbreds. Thirty-four hybrids had U.S. inbreds as the ear parent and 22 had Guatemalan corns as the ear parent. The experimental hybrids were planted at Shenandoah, Iowa, in April, 1946, together with the seven U.S. inbreds and the Guatemalan corns used to produce the hybrids.

The hybrids made on the U.S. inbreds as the ear parent tasseled earlier than those made the other way. All the Guatemalan hybrids flowered later than the U.S. inbreds and had 18 to 22 functional leaves, or about two more than the commercial hybrids. The open-pollinated Guatemalan corns had 20 to 26 leaves. The leaf number of the hybrids was intermediate between the inbred line and the Guatemalan corns.

The ears of the hybrids with U.S. inbreds as ear parents were more like the inbreds than when made the other way. The hybrids produced uniform cylindrical shaped ears characteristic of the U.S. inbreds rather than the conical shaped ear typical of the Guatemalan maize. Kernel color, shape and character of endosperm varied. Just why the hybrids seemed to be so influenced by the U.S. inbred parents is not evident from the data in hand.

Lodging was largely absent in the Guatemalan hybrids and pronounced in United States commercial hybrids as brought on by two wind storms just after the corns were in the hard dough stage. The root systems of the Guatemalan hybrids were larger than those of the U.S. corns.

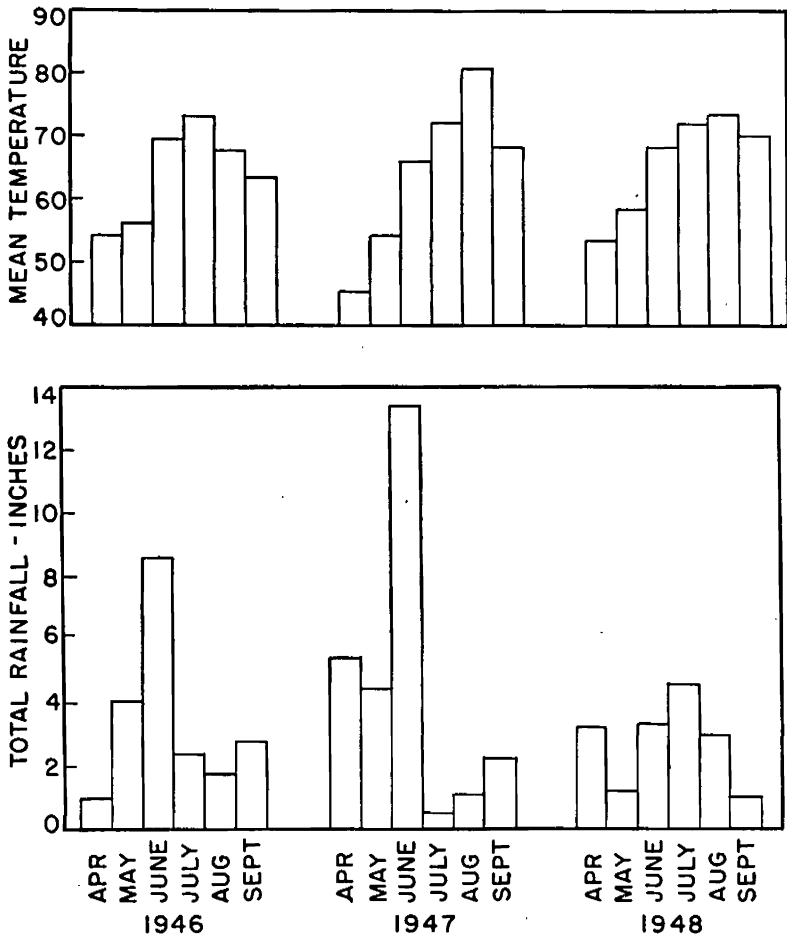


Fig. 1. The mean temperatures and total rainfall for the 6 months' growing seasons of 1946, 1947 and 1948 at Ames. The Iowa state corn yields for 1946 were 60 bushels; 1947, 47 bushels; and 1948, 61 bushels per acre. The year 1947 was dry in July and August and unusually hot in August, which cut the yield approximately 300 million bushels.

Maturity was the most significant observation in the hybrids. Although the plants flowered 1 to 3 weeks later than the U.S. inbreds, they all matured some good ears before the frost. This indicated that good quality seed could be expected from hybrids.

TRIALS AT AMES IN 1947

In the trial plots of Shenandoah, Iowa, in 1946, individual plants of the F_1 generation were self pollinated and crossed onto parental inbred lines to form backcrosses and onto other inbred lines to form three-way crosses. In addition, new hybrids between U.S. inbred lines and

TABLE 1. GROWTH RESPONSE OF U. S. COMMERCIAL HYBRIDS, SINGLE CROSSES AND EXPERIMENTAL GUATEMALAN HYBRIDS, AT AMES, IOWA, U. S. A. IN 1947.

Crosses	Pedigree	Group* (Guatemalan parent)	Average height (feet)	Average no. leaves	% leaf area alive	No. lodged	Days to shedding	Length of ears (inches)	Kernel type**	Color	Percentage moisture	Average wt. per ear (lbs.)
U. S. Double	Ia.4397	—	6.6	13	0	20	72	6-10	D	Y	25.4	0.37
"	US.13	—	6.9	16	15	15	72	8-10	D	Y	20.7	0.43
"	US.35	—	6.5	14	20	7	72	8-10	D	Y	20.0	0.47
U. S. Single	M14xWF9	—	—	—	—	—	72	6-8	D	Y	20.8	0.32
"	M14xW22	—	—	—	—	—	—	—	—	—	—	0.33
Guate. single	Trx1487-45	H	7.4	16	50	0	72	10-12	SD	Y	35.0	0.38
"	L317x7-46	ED	9.5	17	70	0	86	8-10	SD	Y	36.0	0.35
"	L317x1487-45	H	9	16	40	0	72	8-10	SD	Y	27.6	0.37
"	L317x1667-45	C	9	16	60	0	86	8-10	SD	YW	34.2	0.29
"	38-11x1443-45	C	9	16	55	0	72	10-12	SD	YW	31.4	0.40
"	Trx7-46	C	7	16	70	0	86	8-10	F	Y	31.6	0.39
"	Hyz1487-45	H	6.8	15	58	8	72	6-10	D	Y	27.5	0.34
"	Hyz1561-45	M	7	15	35	4	72	10-12	D	Y	23.1	0.43
"	R4x23-46	C	—	14	—	—	72	10-12	D	Y	20.0	0.47
"	38-11x1614-45	C	8	15	70	0	72	10-12	SD	Y	33.7	0.35
"	38-11x7-46	C	7.4	15	70	0	86	6-8	F	Or	39.0	0.30
"	38-11x26-46	C	7.4	16	57	0	86	6-10	D	Var	35.2	0.30
"	38-11x30-46	ED	7.4	15	63	0	86	6-8	SD	Y	32.0	0.28
Guate. three-way crosses	420x(WF9x31a)	H	7.1	14	43	0	72	8-10	D	Y	20.8	0.56
"	M14x(31axWF9)	H	7.2	14	50	0	72	8-13	D	Y	29.7	0.45
"	M14x(WF9x31a)	H	7	14	60	0	72	10-12	D	Y	27.0	0.52
"	WF9x(M14x194-44)	H	7.1	14	50	0	72	10-12	D	Y	28.6	0.51
Guate. back-crosses	M14x(M14x31)	H	6.9	15	30	0	72	8-10	D	Y	24.8	0.39
"	420x(61dx420)	C	6.7	13	25	0	72	10-12	D	Y	15.4	0.44
"	WF9x(61bxWF9)	C	6.5	16	65	0	72	6-8	D	Y	32.8	0.53
"	M14x(31xM14)	H	6.8	16	30	0	72	8-10	SD	YO	19.2	0.40
"	M14x(M14x194-44)	H	6.4	12	50	0	72	6-10	SD	Y	49.4	0.51
"	O7x(O7x62-44)	H	—	—	86	—	86	7-10	SD	Y	33.3	0.30

*Groups of corn:

ED = Early dwarf

H = Highland

M = Mountain

C = Coast

**The character of kernels was recorded as nature of endosperm and color:

F = Flint

D = Dent

SD = Semi-dent

Y = Yellow

W = White

YW = Mixed yellow and white

Guatemalan corns were made at the Tropical Research Center in Antigua, Guatemala, in 1946. The pedigrees of some of these are shown in table 1.

Sixty-eight of these hybrids were planted at Ames, Iowa, on May 10, 1947. Three U.S. commercial double crosses and three U.S. single crosses were included in the plots for a comparison of growth. In an adjoining plot 30 open-pollinated Guatemalan corns were planted. The Guatemalan hybrids consisted of 16 top crosses (U.S. inbreds x open-pollinated Guatemalans), 34 self-pollinated ears of F_1 hybrids, 7

backcrosses and 5 three-way crosses. The response of only 23 of the 68 Guatemalan hybrids and five U.S. hybrids are shown in table 1.

The 1947 growing season was unfavorable for corn. The rainfall and temperature for the 3 years, 1946, 1947 and 1948 are shown in fig. 1. The state corn yields for the three years, 1946, 60 bushels per acre; 1947, 47; and 1948, 61. Plainly the weather conditions for 1946 and 1948 were much more favorable for the growth and development of the corn crop than was that for 1947. The 1947 rainfall was unusually high in June (more than 13 inches) and unusually low in July and August. August was very hot with a mean of over 80° F. These weather conditions were important contributing factors to the low state yield in 1947, which was more than 300 million bushels lower than the preceding or following years.

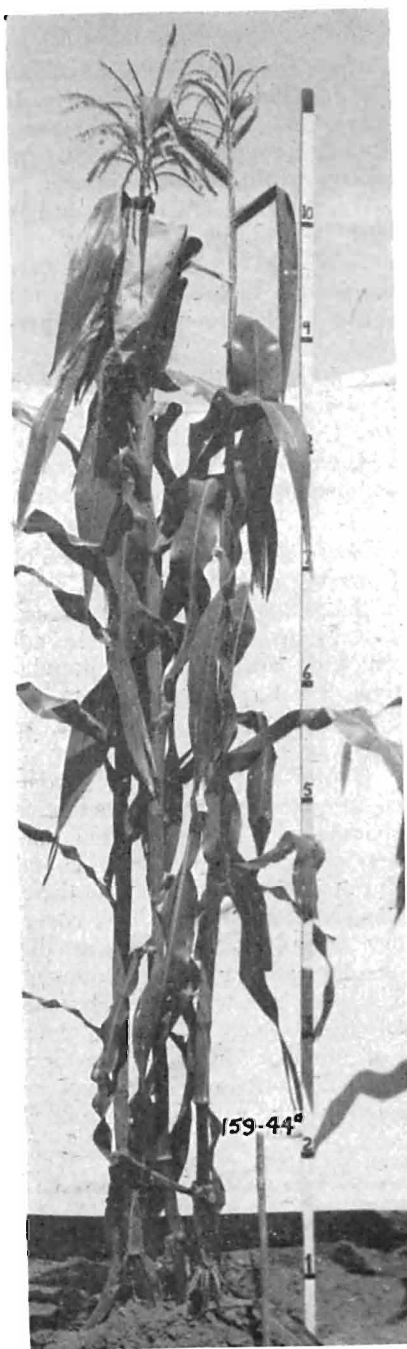
The open-pollinated Guatemalan corns developed in the same way in 1947 as they did in 1946 in southwestern Iowa. Many of them did not shed pollen until late September. A few Guatemalan early dwarf and coast corns developed some mature seed. Number 7A-46, a coast corn, was one of these. (See figs. 2 and 3 for response of Guatemalan corns at Ames and Antigua in 1948.)

The F_1 hybrids and F_2 populations showed wide variation in time of flowering and maturity, but some of the plants matured before frost. The F_1 hybrids matured in advance of most of the F_2 populations. The F_2 populations were less uniform than the F_1 hybrids, as might be expected.

Similar sharp differences existed in vegetative and reproductive characters. The pollination was very poor in some F_1 hybrids and F_2 populations and good in others. The shank length and husk coverage varied considerably as did also the ear and kernel characters. The same was true for such vegetative characters as plant height, leaf number and root development. Mature ears developed on some plants with 75 percent of



Fig. 2. A Guatemalan corn, 31b, a representative of the highland group grown at Ames, photographed Sept. 25, 1947. This corn was just beginning to flower. Note the strong vegetative development consisting of large, well rooted stalks with 20 to 24 leaves above to soil line. The leaves are broken at the junction of the blade with the leaf sheath and hang down paralleling the stalk. The tassel and youngest leaves droop as though wilted. The gross aspect of the plant differs from its appearance in the highlands of Guatemala.



the leaf surface green and alive on Sept. 25 when neighboring U.S. single crosses were nearly all dead. The production of mature ears on green stalks was a striking characteristic, suggesting that the individual plants carried the vegetative vigor of the Guatemalan parents and the early maturity of the U.S. inbreds. It should be noted, however, that the maturity of these hybrids was later than the standard U.S. hybrids which, in part, may account for their greater percentage of green leaf surface.

Probably the most interesting response was obtained from backcrosses and three-way crosses. These were earlier than the F_1 hybrids and approached the maturity period of the U.S. commercial hybrids. The backcrosses generally were more vigorous than the U.S. corns, producing larger and heavier ears. (See table 1 and figs. 4, 5 and 6.) In some backcrosses and three-way crosses there was evidence of poor combining ability since the plants were low in vegetative vigor and ear shoot development. Some developed branched ear shoots.

The differences in the vigor of the Guatemalan hybrids and the U.S. commercial hybrids were apparent in the number of green leaves on Sept. 25. On this date the green leaf area on the three U.S. commercial hybrids was: Iowa 4397, none; U.S. 13, 25 percent; and U.S. 35, 20 percent. The four three-way crosses shown in

Fig. 3. This is a hill of corn representative of the highland group growing in its native habitat in Antigua (altitude 4,853 feet). Compare these plants with those grown at Ames in fig. 1. The difference in this response and general appearance is due to climatic differences of the two locations.



Fig. 4. A commercial hybrid, U.S. 35, grown at Ames in 1947. This corn was injured by hot dry summer weather. The ruler was 6 feet long. Only 20 percent of the leaf surface was green on Sept. 25. Compare with fig. 5.



Fig. 5. A backcross, $M14 \times (31 \times M14)$, growing at Ames on Sept. 25, 1947. No. 31 is a Guatemalan highland corn. This backcross had 30 percent green leaf area. The ruler was 6 feet long.

table 1 ranged from 43 to 60 percent alive and green, and in the six first backcrosses from 30 to 65 percent. The ears showed a strong tendency to ripen on a green stalk with more than half of the leaf surface still alive and functioning. The root systems of these three-way and backcrosses were larger and freer from root lesions than those of the U.S. corns. Lodging differences further indicate this difference in the root systems.



Fig. 6. Ears produced by the backcross M14x(31xM14). The average dry weight per ear was 0.40 pounds.

The low moisture content at harvest on October 14 (table 1) indicated that the Guatemalan hybrids produced corn of good quality.

It should be pointed out that the U.S. corns did not mature normally. The stalks, leaves and roots died prematurely from the effects of the unfavorable weather conditions already described. The Guatemalan hybrids maintained a green leaf surface longer than the U.S. corns, which permitted the ripening of the ears on green stalks with from 30 to 65 percent of the leaves alive.

Three facts emerged from the 1947 trial: First, backcrosses of the F_1 hybrids with the U.S. inbreds made possible the maturity of the ears while the leaves of the plants were still green. Second, the tolerance of hybrids to the hot dry weather of July and August was evident. Third, the large root systems in the hybrids were freer of root lesions than the U.S. commercial hybrids. The interpretation of the response of the backcrosses was not apparent from the data in hand and warrants further exploration with more uniform Guatemalan germ plasm. The responses to the 1947 dry season suggest that Guatemalan germ plasm in certain hybrid combination may reduce the injury now occurring to our U.S. commercial hybrids from hot dry weather in July and August. It is not enough for a commercial hybrid to yield well only in favorable seasons. As is well known, a commercial hybrid should be so fortified that it responds well under adverse conditions also, especially heat and drouth that intermittently visit the corn belt.

TRIAL AT AMES, IOWA, IN 1948

Since the 1947 growing season was unfavorable for the best response of U. S. hybrids, a further trial was conducted the following year, 1948, when the growing conditions were expected to be more favorable for the U. S. hybrids. In such a season the hybrids containing Guatemalan germ plasm might respond very differently and possibly less favorably than in 1947. This led to two tests of different collections of Guatemalan hybrids in 1948 at Ames.

RESPONSE OF 19 THREE-WAY HYBRIDS WITH ONE GUATEMALAN PARENT

The first of these tests consisted of 18 hybrids between different Guatemalan corns and the U.S. single cross WF9x38-11 as the common male parent, one three-way with two U.S. inbred parents and seven U.S. hybrids of four single crosses and three four-way crosses. The seeds were planted May 14 in randomized complete blocks of four replications. The rows were 50 feet long and 3 1/3 feet apart with 50 seeds spaced 1 foot apart in the row.

The growing season of 1948 proved especially favorable. (See fig. 1.) The U.S. hybrids grew 7 1/2 feet tall and flowered in 67 to 72 days. Their average dry ear weight of 0.38 to 0.51 lbs. was low because of the low fertility of the soil. The first 18 three-way hybrids in table 2 were taller and took longer to flower. Their average dry weight of ear varied from 0.17 to 0.47 lbs., generally lower than the U.S. hybrids.

TABLE 2. GROWTH AND DEVELOPMENT OF 19 THREE-WAY CROSSES (GUATEMALAN X U.S. SINGLE CROSS WF9x38-11, 1 THREE-WAY (ONE GUATEMALAN PARENT, TWO U.S.), 4 U.S. SINGLE CROSSES AND 3 U.S. FOUR-WAY CROSSES AT AMES, IOWA, IN 1948, PLANTED MAY 14.

Crosses	Pedigree	Days to flowering	Plant height (feet)	Ear height (inches)	Av. ears* per plant (lbs.)	Av. dry wt. per ear (lbs.)	Moisture percent	Quality** grain
Guat. three-way	64-44*x (WF9x38-11)	79	9 1/2	6	0.82	.40	19.8	E
	86.44*x (WF9x38-11)	83	10	6	0.48	.28	31.5	F
	91-44*x (WF9x38-11)	79	10	6	0.68	.33	20.5	E
	7A-46x (WF9x38-11)	79	10	5 1/2	0.79	.44	21.7	E
	7A1-46x (WF9x38-11)	79	9 1/2	6	0.84	.44	22.4	E
	7A2-46*x (WF9x38-11)	79	9 1/2	5 1/2	0.62	.37	25.4	E
	11A-46x (WF9x38-11)	81	9 1/2	6	0.72	.36	24.5	E
	12-A-46*x (WF9x38-11)	83	10	6	0.54	.27	30.3	E
	34A-46*x (WF9x38-11)	81	10	6 1/2	0.74	.37	24.7	E
	118A-46*x (WF9x38-11)	81	9 1/2	6	0.61	.37	24.6	E
	338A-46x (WF9x38-11)	83	9 1/2	6	0.66	.34	20.7	E
	175-47x (WF9x38-11)	81	9 1/2	6	0.75	.47	21.5	G
	176-47x (WF9x38-11)	81	9 1/2	6	0.77	.41	26.2	E
	181-47x (WF9x38-11)	81	9 1/2	6	0.71	.41	20.2	E
	182-47x (WF9x38-11)	83	9 1/2	6	0.53	.33	20.2	E
	188-47x (WF9x38-11)	81	9	6 1/2	0.29	.17	35.1	F
	193-47x (WF9x38-11)	83	9 1/2	6	0.75	.43	23.4	E
	199-47x (WF9x38-11)	83	10	6 1/2	0.72	.40	28.9	E
U.S. single	M14x (WF9x31a)	68	7	3 1/2	0.86	.40	13.0	E
	M14xWF9	62	7 1/2	3 1/2	0.98	.38	8.9	G
	M-14xW22	60	7 1/2	3	1.02	.42	8.2	E
	205x234	60	7 1/2	3 1/2	0.90	.51	7.8	G
	WF9x38-11	65	8	4	0.95	.50	11.0	E
U.S. four-way	U.S. 13	62	8	5	0.93	.45	13.2	E
	Ia. 939	61	7 1/2	3 1/2	0.98	.43	12.6	E
	Ia. 4316	62	7 1/2	4	1.01	.42	12.1	E

*Average number of ears per plant included only ears with good grain; nubbins were not counted.

**Quality of grain was estimated:

E = excellent
G = good
F = fair

Too, the percentage of moisture in the ear was higher. This was due to their later maturity, coupled with early harvesting on Oct. 23.

The data suggest that the three-way hybrids using Guatemalan corns as the ear parents have so long a maturity period that frost may, some seasons, injure the grain. However, this didn't happen in 1948 because the growing season was long. The seasonal difference in maturity evident in the Guatemalan corns in their native habitat was not evident when in hybrid combination and grown at Ames. For example, 7A-46, 86-44 and 64-44 are coast corns that flower in 50 to 60 days and mature in about 100 to 110 days in the coastal area of Guatemala. The hybrid 7A-46x(WF9x38-11) grown at Ames required 135 days to mature. Such other corns as 339A-46, 188-47 and 175-47 are highland corns that require 100 to 115 days to flower and 150 to 175 days to mature in their own climate. At Ames their maturity in hybrid combination was shorter, only 140 days.

It would seem then, that despite the wide differences that exist between Guatemalan corns in the time they require for anthesis and ma-

TABLE 3. GROWTH RESPONSE OF 17 GUATEMALAN THREE-WAY CROSSES, 3 SECOND BACKCROSSES, 2 U.S. SINGLE CROSSES AND 3 FOUR-WAY CROSSES AT AMES, IOWA, PLANTED JUNE 5, 1948.

Crosses	Pedigree	Days to flowering	Ear height (feet)	Av. ears* per plant	Av. dry wt. per ear (lbs.)	Percentage moisture	Quality** grain
Three-way	(38-11x1443-45)xWF9	72	3½	1.00	.52	27.7	G
	(38-11x30A-46)xWF9	82	4	.96	.46	20.2	F
	(38-11x7A-46)xWF9	75	4	.77	.53	28.7	F
	(38-11x26A-46)WF9	75	3	.98	.48	23.3	G
	(Hyx7A-46)xWF9	72	3	.88	.53	21.7	G
	(Hyx1487-45)xWF9	74	3	.98	.50	22.8	E
	(07x1578-45)xWF9	75	3	1.05	.48	22.1	E
	(07x7A-46)xWF9	84	4	.74	.38	32.8	P
	(07-23A-46)xWF9	82	3½	.91	.46	27.4	G
	(317x7A-46)xWF9	78	4½	.78	.46	28.6	G
	(317x1667-45)xWF9	82	4	.90	.53	26.2	G
	(R4x1487-45)xWF9	75	3	1.03	.50	23.4	G
	(R4x23A-46)xWF9	75	3	.81	.43	17.5	G
	(Trx7A-46)xWF9	67	3½	.74	.45	32.7	P
	(289x31-44)xWF9	82	3½	1.03	.51	23.8	G
	(K4x1487-44)xWF9	84	4	.78	.40	33.0	F
	M14x(WF9x31a)	70	3½	.86	.40	13.0	E
Second back	[WF9x(WF9x35Y)] xWF9	72	3	.86	.44	23.2	G
	[WF9x(WF9x32)] xWF9	72	3		.46	22.8	G
	[WF9x(61bxWF9)] xWF9	75	3	.94	.44	26.3	G
U.S. single	205x234	75	3	.92	.43	15.6	G
	WF9x38-11	75	3½	.93	.59	20.0	E
Four-way	No. 1	75	3	1.00	.45	19.5	E
	No. 2	75	3½		.48	15.1	E
	No. 3	75	2½		.47	15.4	E

*Average number of ears per plant included only ears with good grain; nubbins were not counted.

**Quality of grain was estimated:

E = excellent
G = good
F = fair

turity in their native habitat, the hybrids produced between them and U.S. inbreds tasseled and matured approximately the same time at Ames.

RESPONSE OF 16 THREE-WAY CROSSES AND 3 SECOND BACKCROSSES

The second test comprised 16 three-way crosses between different F_1 hybrids and the U.S. inbred WF9 as the common male parent, one other three-way $M14 \times (WF9 \times 31a)$, three second backcrosses, each with WF9, two U.S. single crosses and three U.S. commercial hybrids. These were planted at Ames, June 5, about 3 weeks later than the commercial crop. Because of the limited amount of seed, only two randomized blocks were planted. The plots were single rows 25 feet long, 3 1/3 feet apart with 20 seeds planted 1 foot apart within the row. (See table 3.)

The days to flowering ranged from 67 to 84 for the 16 three-way crosses, 70 for $M14 \times (WF9 \times 31a)$, 72 to 75 for the second backcrosses and 75 days for the U.S. hybrids. In other words, the days to flowering of all the hybrids were not very different from one another. The percentage moisture was higher in the 16 three-way hybrids, indicating slight delay in their maturity. Less moisture was present in three-way $M14 \times (WF9 \times 31a)$ where the U.S. inbred was the ear parent. This three-way rated higher in quality than most three-way crosses and equal to the U.S. hybrids. The yields from all the three-way, single and double crosses were not greatly different from one another. They



Fig. 7. The product from two replications of three three-way crosses involving Guatemalan corn, Ames, 1948. The hybrids were $(0h.07 \times 7A-46) \times WF9$, $(38-11 \times 26A-46) \times WF9$ and $(Hy11561-45) \times WF9$. See table 3 for performances.



Fig. 8. The product of two replications of two second backcrosses and one United States commercial hybrid, Ames, 1948. The hybrids were $[WF9 \times (WF9 \times 35)] \times WF9$, $[WF9 \times (61 \times WF9)] \times WF9$ and a U.S. commercial hybrid. See table 3 for performances.

were all low, considering the lateness of planting and lack of soil fertility. (See fig. 7.)

Probably the most interesting result was that from the three second backcrosses in which the ear height, flowering time and ear shrinkage were comparable to the U.S. corns. The moisture percentage was 5 to 10 percent higher than in the five U.S. hybrids, but the weight per ear was not too different, except in the case of $WF9 \times 38-11$: (See fig. 8.) This single cross is generally a high yielder. All of the three-way and second backcrosses showed many of the characters of the U.S. inbreds. The influence of the Guatemalan corns was most apparent in the vegetative stage of the hybrids.

SUMMARY

The climate of the corn belt is unfavorable for the complete development of the reproductive stage of most Guatemalan corns. Variants of the four groups of Guatemalan corns can be crossed with U.S. inbreds and single crosses when climatic conditions are favorable for the development of the reproductive stages of the two parents. The resulting hybrids have matured in Iowa during the past 3 years, 1946 through 1948.

Three-way and backcrosses having one Guatemalan parent in the F_1 mature in fewer days than single crosses (U.S. inbred \times Guatemalan corns).

The three-way crosses made on a U.S. single cross flowered from 10 to 21 days later than U.S. hybrids but earlier than open-pollinated Guatemalan corns grown at two locations in Iowa. The average dry weight per ear of these three-way crosses was generally less than that of the U.S. hybrids.

In three-way crosses with one Guatemalan in the F_1 , the gross characters of the plant were much like those of the U.S. corns and the weight per ear approached or equaled that of the U. S. hybrids.

The characters of the Guatemalan parent were more obvious in the vegetative stage than in the reproductive. On the other hand the characters of the U.S. inbreds and single crosses were most pronounced in the reproductive stage.

First and second backcrosses involving certain Guatemalan corns showed little loss of vigor and a strong tendency to produce ears with the dry weights approaching those of some U.S. hybrids.

The data accumulated on the growth and development of Guatemalan corns crossed on U.S. inbreds and grown in Iowa, indicated that characters believed to enhance U.S. hybrids can be brought to the corn belt in hybrid combination and studied under field conditions, thus making available to students of corn a hitherto only partially explored pool of maize germ plasm.

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Estudio Preliminar Del Desarrollo De Los Híbridos Entre Maíces Guatemaltecos Y Estadounidenses

RESUMEN

POR I. E. MELHUS, GEORGE SEMENIUK Y J. R. WALLIN
IOWA STATE COLLEGE-GUATEMALA TROPICAL RESEARCH CENTER

El clima de la región maicera de E.E.U.U. es desfavorable para el desarrollo completo de la fase reproductiva del maíz guatemalteco. Sin embargo, se pueden cruzar las variantes de los cuatro grupos de maíz guatemalteco, con líneas puras e híbridos simples de E.E.U.U. cuando las condiciones climáticas son favorables para el desarrollo de la fase reproductiva de ambos padres. Los híbridos resultantes han madurado en Iowa en los últimos tres años, 1946, 1947 y 1948; es mas, se ha observado que en Iowa los three-way's y los cruces de retorno que contienen un padre guatemalteco maduran antes que los cruces simples (Maíz guatemalteco X Línea pura de E.E.U.U.), habiendo madurado los últimos, cerca de 10 a 21 días mas tarde que los híbridos estadounidenses pero antes que los maíces guatemaltecos libremente polinizados. El peso seco medio de maíz por mazorca, producido por los cruces simples antes mencionados era menor que el producido por los híbridos norteamericanos.

Se pudo notar que los caracteres generales de los cruces de retorno se asemejan mas a los de los híbridos de E.E.U.U. y que el peso por mazorca es casi el mismo. Los caracteres del padre guatemalteco eran mas aparentes en el desarrollo vegetativo, al tiempo que en el reproductivo predominaban los del padre estadounidense, y, los primeros y segundos cruces de retorno conteniendo un padre guatemalteco mostraban poca pérdida de vigor.

Los datos acumulados sobre el desarrollo de los cruces simples entre maíz guatemalteco y estadounidense, parecen indicar que algunos caracteres, que, se estima, puedan mejorar los híbridos de E.E.U.U. pueden traerse a la región maicera de E.E.U.U. en forma de híbridos para su estudio, proporcionando asi una fuente de plasma germinal hasta hoy poco explorada.

Official Opening of the Iowa State College-Guatemala Tropical Research Center¹

Opening the Center

BY CHARLES E. FRILEY
PRESIDENT, IOWA STATE COLLEGE

It is my pleasant privilege to extend to this audience the official welcome of the Iowa State College-Guatemala Tropical Research Center, and to assure each of you of the deep personal satisfaction which Dr. Melhus and I feel because of your presence and your interest in the program.

The Tropical Research Center is an integral and important part of the research and educational program of the Iowa State College; and in that program the researches in agriculture and the related sciences occupy the most prominent place.

Further, since corn is the most important crop in Iowa and the Midwest, and since we are working constantly to improve this great agricultural product, it was natural that we should turn to that part of the world—the country of Guatemala—in which corn has been indigenous for thousands of years. The early exploration of Dr. Melhus and his associates in this country revealed the presence of many varieties and types of corn, and this fact naturally inspired the hope that important characteristics might be found of value to the corns of the United States. At the same time we desired to be of service to the agricultural interests of Guatemala, recognizing that an increasingly prosperous agriculture in our country and in that of our neighbouring countries will be mutually beneficial.

The preliminary work of the Center has been successful beyond our expectations. Dr. Melhus and I recognize that much of this success is due to the intelligent and sympathetic cooperation of the Minister of Agriculture of the Guatemalan Government, the United States Ambassador, the Director of the National School of Agriculture, the May Seed and Nursery Company, the United Fruit Company and representative agriculturists throughout the country. To all of these agencies and individuals we express our sincere appreciation and gratitude.

And now, with the foundations well established, and encouraging prospects for a constructive program in the future, I have the honor to declare the Iowa State College-Guatemala Tropical Research Center officially opened, and dedicated to a better agriculture for the Americas and to a closer understanding and friendship between the people of Guatemala and the United States.

¹Talks given at the program marking the official opening of the Center at Antigua, Guatemala, March 5, 1948.

Some Events in the Life of the Late Earl E. May

BY MRS. GERTRUDE MAY

VICE PRESIDENT, EARL E. MAY SEED COMPANY

You doubtless recall that John Ruskin was an architect as well as a writer, and that his love of architecture is reflected in many of his beautiful prose compositions. My husband was particularly fond of the following quotation from Ruskin: "Therefore when we build let us think that we build forever. Let it not be for present delight nor for present use alone, let it be such work as our descendants will thank us for; and let us think as we lay stone upon stone that a time will come when those stones will be held sacred because our hands have touched them, and that men will say as they look upon the labour and the wrought substance of them, 'See, this our fathers did for us!'"

I have prefaced my remarks with that quotation because it epitomizes my husband's philosophy of life. It helps us to understand why a man whose efforts were largely devoted to founding and managing a large business enterprise would make a substantial grant for research which would benefit other companies as well as his own, and the fruits of which might not be realized in his lifetime.

Mr. May was born and raised on a farm in western Nebraska. His people were successful farmers, but that section of our country fails to produce a crop in some years due to lack of rainfall and other adverse weather conditions. It was therefore necessary for him to earn money to help pay for his education. He did so by teaching school and, during summer vacations when he was studying law at the University of Michigan, he sold seed for the D. M. Ferry Seed Company, traveling on horseback through the hilly sections of several of our southeastern states.

We were married shortly after he received his Bachelor of Law degree from the University of Nebraska. Instead of practicing law he decided to start a seed and nursery company and sell by mail order instead of traveling from place to place on horseback as he did when he sold seed for the D. M. Ferry Company.

A few years after he started his seed and nursery business he became interested in the possibilities of radio as an advertising medium. So he built a radio station. I wish I had time to tell you of all the things that happened while these two businesses were growing up, but that would take too long. There were many problems and many disappointments. There were depressions, dry years, wet years, and troubles with wave lengths for the radio station. But things came out all right and now the May Seed and Nursery Company, in addition to mailing hundreds of thousands of catalogs, has a chain of 29 retail stores in the states of Iowa, Nebraska, Missouri and Kansas, and is known all over the United States. The radio station, KMA, is one of the outstanding regional stations of the country, and several times has been awarded a bronze plaque for being the leading farm station in the

United States. The Seed and Nursery Company and Station KMA have both become institutions, so to speak, in our section of the United States, which we refer to as the Middlewest.

Someone has said that, "an institution is but the lengthened shadow of a man." If that is true, the two institutions he founded are a measure of the stature of Mr. May. I think they are. In order to build his business he had to gain the confidence of people who bought seeds and nursery stock and who listened to him in his daily broadcasts over the radio. In order to gain their confidence he had to merit it, and in order to merit it he had to demonstrate that his interest in them was not entirely a selfish one.

I could give you many examples of his keen and friendly interest in the welfare of his customers and his radio audience. He loved to travel and knew that others did too but were unable to do so because of the expense. Mr. May contacted railroads and steamship companies and worked out a European tour that was very reasonable in cost. He told about his plan over the radio with the result that hundreds of people made the trip to Europe with him.

On a vacation in Florida he was impressed with the excellent taste and flavor of tree-ripened citrus fruit compared to the cold storage kind we could buy in the Middlewest. He made arrangements to have several cars shipped to Shenandoah, but the long freight haul did not leave the fruit nice and fresh like it was in Florida; so he made a trip to the citrus groves of Texas, which is much closer to Shenandoah than Florida, and now, each year, for 3 months during the winter, fresh tree-ripened oranges and grapefruit are available at all of our stores. People buy this fruit by the bag and during those 3 winter months we handle 70 or 80 carloads. That is probably as much citrus as all of the grocery stores in Iowa combined sell during the same period of time.

Mr. May made several trips to Mexico. He loved its climate, its beauty and its people. He visited with all classes of folks—with the boys who shined his shoes, with barbers and taxi-drivers, and with men in high positions in the government. He brought two fine Mexican boys to Shenandoah. They worked at the seed house and lived with us in our home, and in this way we learned a great deal about the history, crops, climate and people of Central America.

This was a challenge to Mr. May, and he became enthusiastic to do something to promote agricultural research because he was convinced that such research would benefit both Central and North America. He visited about such a program with Dr. Melhus, Dr. Friley and others at Iowa State College and found them as enthusiastic about it as he was. It was decided that basic research in corn would be of greatest benefit to agriculture and in order to get it started Mr. May gave the \$75,000 grant to the College.

The establishment of a Tropical Research Center became a reality. Today this Center is being dedicated. Under the able direction of Dr. Melhus, wonderful progress has already been made. Many selections

of Central American corns are being tested, purified, and crossed with corns of the United States. Their performance is being checked against the performance of our present hybrids. The results are most encouraging. Much work remains to be done, but I am confident that in the not too distant future the Experiment Station at Iowa State College will be releasing inbred lines with desirable Guatemalan characteristics in them.

I am proud of the part my husband had in bringing this about, and I am happy in the knowledge that while this is taking place, Guatemala and other countries of Central America will also be benefiting through greatly increased yields of corn and other crops as a result of the work being done at the Tropical Research Center in this beautiful, friendly and cooperative country of Guatemala.

Cooperation in Agriculture

BY EDWIN J. KYLE

U. S. AMBASSADOR TO GUATEMALA

The four most important food crops in the world, judged so by the number of people dependent upon them for their principal sustenance are rice, wheat, potatoes and corn. All four of these food crops are produced very successfully in Guatemala. Two of them, namely corn and potatoes, are supposed to have originated in Guatemala.

Nature has been very kind in producing factors that are important to the agricultural economy of Guatemala. The soils and climate of this beautiful country are well suited for the production of a wide variety of crops. I am convinced, after a careful inspection of most parts of Guatemala, that considering its size, it produces a greater variety of flowers, fruits, vegetables and general farm crops than any other country in the world.

It has been my pleasure and privilege since coming to Guatemala to cooperate with the people and the Government of Guatemala in doing everything possible to improve on the varied agricultural economy of this fine country. This has taken the form of:

- (1) Protection and improvement of soils by terracing and by the use of commercial fertilizers and the introduction of leguminous plants.
- (2) The introduction of new varieties and improved methods of harvesting and finishing of rice, cane and coffee.
- (3) The introduction of new varieties of fruits and vegetables.
- (4) Introduction of new varieties of wheat.
- (5) Encouragement of the expansion and development of means of transportation to make transporting food products to market easier.
- (6) Obtaining scholarships and encouraging young men to prepare themselves through college training for leadership in agriculture.
- (7) Conducting tours of leading agriculturists through the most important agricultural regions of the United States.
- (8) Cooperating with other agencies in the improvement and development of agricultural crops in Guatemala.

Among these agencies, it has been a special pleasure and privilege to cooperate in every way possible with the Iowa State College-Guatemala Tropical Research Center in the fundamentally important work it is doing on the study and improvement of corn and other crops of importance to Guatemala and the world. The fact that a very large percentage of the people of Guatemala are dependent upon corn as their principal food, stamps this native crop as of great and vital importance to the Government and people of Guatemala. I am convinced that the results that will come from this study of corn will prove to be one of the most important and valuable services that has ever been rendered to this country, and that it will prove to be one of the most powerful agencies in promoting good will between Guatemala and the United States.

I wish, therefore, to bow in grateful reverence to the memory of the late Earl E. May, whose generosity has made possible this important program, and I commend and compliment his widow, Mrs. Gertrude May, for her interest in this work and her presence here today. I wish also to compliment and commend Dr. I. E. Melhus and his corps of able scientists for the remarkable plan they have worked out and the scientific application they are making in the work of this organization. It is fortunate that the United States has a renowned institution like the Iowa State College, and a broad-visioned president, Dr. Charles Friley, who can sponsor and encourage such a great and vitally important movement.

Coöperation of Private Enterprise in Corn Improvement

BY PEDRO G. COFINO

FINCA RETANA, ANTIGUA, GUATEMALA

The increase in corn production is of world importance due to its various uses as food and raw material for industry. It is of still greater importance to Guatemala being the basis of food for a large percentage of the population.

Our production being mostly in the hands of small farmers, yields are very low, due to absence of seed selection and obsolete systems of cultivation.

It is necessary to make a scientific selection and improvement of seed corn, to investigate new systems to improve soil fertility and introduce the use of modern agricultural implements. We must also improve the plant's resistance to adverse weather conditions, diseases and insect attacks.

These improvements in seed and cultivation will reduce cost of production, thus extending its use as cattle feed and for industrial purposes. They will also improve our economy by discontinuing imports of grain.

I believe this improvement can only be reached through scientific investigations, taking advantage of work already advanced in the United

States, and for this reason I consider the program being carried on by the Iowa State College through its Tropical Research Center to be of great interest. It will no doubt improve production in the whole world.

Private enterprise must cooperate in this research by encouragement shown by interest in these experiments, giving free use of land, implements and agricultural machinery and with sufficient funds to permit continued research until final results are reached.

I am sure that with the interest now being shown in the work of Dr. Melhus and his associates, we will find ways and means of extending our full cooperation.

Plant Resources of the American Tropics

By I. E. MELHUS

DIRECTOR IOWA STATE COLLEGE-GUATEMALA TROPICAL RESEARCH CENTER

It is a great pleasure to have this distinguished body as guests of the Tropical Research Center. First, because it is an unusual occasion, the official opening of a branch of a technological institution in a foreign country. This has never occurred before anywhere in the Western Hemisphere. We have come here in the spirit of social and economic betterment, not alone for our own state of Iowa and Guatemala, but for the whole world. Research and higher education never can be kept within state or national boundaries. Research and education ultimately reach every corner of the earth unless restricted by the wrong kind of governments. We have chosen to work in Guatemala because of its immense unexplored plant resources.

When the European nations settled the Western Hemisphere they brought their culture, their religion, their philosophy, their arts, their education and their agriculture. For more than 450 years we have looked chiefly to the land of our forefathers for all that was finest and best in the world. Only those natural resources that might be had for the mere taking in this new world were utilized. Thus it was that maize came to us, when two Spaniards, whom Christopher Columbus in 1493 delegated to explore the interior of Cuba, returned with a report of a grain called maíz, which was pleasing to the taste when baked. Maize was here in the Western Hemisphere available to the white man with little effort, a treasure of immensely greater value than the spices that Columbus sought to find by a new route to India. This cereal played an important role in the colonization of America by the people of Europe. It is well known that the Plymouth colony first came to know the real value of corn as a human food when they were on the verge of starvation, 127 years after Columbus discovered America. In other words, necessity forced our ancestors to adopt a western hemisphere plant that had supported American civilizations for centuries.

The discovery and utilization of the Irish potato, another western hemisphere plant, was not so different from that of corn. Sir Francis Drake introduced the potato into Europe in 1586, but it remained only

a curiosity, until famine stalked in European countries. In France a chemistry professor recognized its desirable food value. He tried in vain to awaken his countrymen to its possibilities. The starving refused to listen. Finally he obtained an audience with the King and pointed out the connection between mass starvation and revolution. The next evening when the monarch took dinner he wore the lavender blossoms and ate the potage made from the potato. The news spread all over France. The shrewdness of the King saved France from bleak famine and taught Frenchmen the food value of the American potato.

Tobacco was here when our forefathers came to America and the Indian taught him how it was used. Around this plant has developed a prosperous agriculture and a rich industry in this hemisphere.

In more recent times American agriculture inherited its short staple cotton from Middle America. This plant has become the cotton belt of the United States and in its shadow has arisen a great industry. The short staple cottons cultivated today differ very little from the original varieties introduced from Mexico.

It is well known that from the American tropics have come many other plants that support our agriculture, such as beans, peppers, tomatoes, sweet potatoes, musky and fig-leaved pumpkins, chioté, pecan, henequen, papaya, the Hevea rubber tree, Peruvian bark tree, chincona (source of quinine), ground cherries, strawberries, cacao, avocado, vanilla, cosmos, zinnia, dahlia and morning glory.

These new crops needed only to be cultivated, harvested and exploited, and it was done when the sciences were in their early stages of development.

This rich heritage, together with the Old World cereals, and the European colonization of the rich fertile lands of the Americas, Africa and Australia, made possible the use of agricultural machinery and the industrial revolution of the last century. For the first time in the world's history, agriculture was able to produce enough food that many hands might be spared from that task and turned to serve the machines. Thus it was that the nineteenth century became the golden age of abundance. Except for this brief period, food has been man's chief preoccupation through his long history.

It is significant that all of this development of the plant resources of the American tropics came about when the sciences were in their infancy. For example, it was done before the discoveries of X-rays; the mode of transmission of yellow fever and malaria, and the resulting methods for their control; the rapid development of internal combustion engines and motor cars; the long distance transmission of electric energy; the laws of Mendelism; the cotton-gin, telegraph and telephone; anaesthesia in medicine; viruses in plants, animals and man; and many others that have profoundly changed the world.

Today, as we approach the end of the first half of the twentieth century, the picture is changed; man is again faced with a world shortage of food due to immense population increase and the ruin of millions of acres of our fertile lands by erosion. In the words of S. B.

Pearson, chairman of the United Nations Interim Commission on Food and Agriculture, "Millions of men, women and children are haunted by constant fear of starvation, and millions more are handicapped from birth to death by hunger and malnutrition . . . Hunger is a menace to peace, security and human welfare." The conclusion is unavoidable, that mankind is fighting a slow retreat before the gathering forces of overpopulation and famine. There are no longer vast expanses of fertile lands to be exploited as was done in the eighteenth and nineteenth centuries. There seems to remain only one great unexplored land area and its plant resources, the tropics.

Here there are countless acres that can be cultivated and made to yield large quantities of food and textiles and home-building materials, the prime requisites of all peoples.

Here the chlorophyll traps the sun's energy 12 months in the year, and the trade winds water the soil in season. The rivers and streams are numerous and ready to supply water where the rainfall is low. Coupled with these physical resources there is a rich flora that holds almost a monopoly in the manufacture of those substances that are of primary importance to life, as carbohydrates, amino acids, vitamins, oils and a long chain of other products that are, or may become, immensely useful. The potentialities for the production of raw plant material in the tropics are so vast as to be difficult to comprehend.

It seems reasonable to believe that as the American tropics provided the world with many crop plants that have had a large part in feeding the world in the past, it will do the same in the future. These rich, virtually unexplored, resources may well stem the forces of famine.

Today we approach the utilization of the plant resources of the tropics, not with the sciences in their early stages of development, but with two centuries of scientific discoveries to fortify us. As a result we now look with eyes and work with tools that see further and penetrate deeper than at any time in the past. It is with these new eyes and tools, supported by new knowledge, that all nations must again search the tropics with their centers of plant creation for new and untapped resources not apparent to primitive man.

Thus it was that the Iowa State College came to establish an outpost, the Tropical Research Center, here in tropical Middle America, side by side with other research agencies engaged in exploring the plant resources of the tropics.

What the fruits of our labors may bring, we can only conjecture, but it is safe to venture the prediction that the discoveries and accomplishments will be of fundamental importance. And these discoveries will not become the property of any one nation; they will become universal and bid fair to lead to the social betterment of all peoples. This was the vision of the late Earl E. May, donor of a grant that has made possible, in a large measure, the official opening today of this outpost devoted to research and higher education, the Iowa State College-Guatemala Tropical Research Center.

Inauguración Oficial Del Iowa State College- Guatemala Tropical Research Center

RESUMEN

POR CHARLES E. FRILEY

VICE PRESIDENT, EARL E. MAY SEED COMPANY

Es para mi un agradable privilegio dar a esta audiencia la oficial bienvenida en nombre del Iowa State College-Guatemala Tropical Research Center y asegurar a cada uno de Uds., la profunda satisfacción personal que el Dr. Melhus y yo sentimos por su presencia aquí y su interés en este programa.

El Tropical Research Center es una parte importante e integral del programa de estudios del Iowa State College y en este programa los estudios sobre agricultura y todo lo relacionado con la ciencia de la misma, ocupan el lugar más prominente.

Además, como el cultivo del maíz es el más importante en Iowa y en el Medio Oeste de los Estados Unidos y ya que nosotros estamos trabajando constantemente para mejorar este gran producto agrícola, fué natural que nos volviésemos a esta parte del mundo—el País de Guatemala—de donde el maíz es nativo. La primera exploración del Dr. Melhus y sus asociados en este país, reveló la presencia de muchas variedades y tipos de maíz y ello naturalmente inspiró la esperanza de que importantes características pudieran ser de algún valor fundamental para el maíz de los Estados Unidos. Al mismo tiempo nosotros deseábamos ser de algún servicio a los intereses agrícolas de Guatemala, ya que reconocemos que con el incremento de la agricultura en nuestro país y en los países vecinos, nos beneficiaremos mutuamente.

El trabajo preliminar del Tropical Research Center ha tenido mucho más éxito del que esperábamos. El Dr. Melhus y yo reconocemos que mucho de su éxito se debe a la inteligente y amable cooperación del Ministro de Agricultura del Gobierno de Guatemala, a la del Embajador de los Estados Unidos, la del Director de la Escuela Nacional de Agricultura, la de la May Seed & Nursery Co., la de la United Fruit Co., y la de los más destacados agricultores del país.—A todas estas personas y entidades expresamos nuestro sincero aprecio y gratitud.

Y ahora, con las bases bien establecidas y alentadores prospectos para un programa constructivo en el futuro, tengo el honor de declarar el Iowa State College-Guatemala Tropical Research Center, oficialmente abierto y dedicado al mejoramiento de la agricultura en las Américas y a estrechar el entendimiento y amistad entre el pueblo de Guatemala y el de los Estados Unidos.

Algunos Sucesos En La Vida Del Extinto Earl E. May

POR MRS. GERTRUDE MAY

VICE PRESIDENT, EARL E. MAY SEED COMPANY

Uds. sin duda recordarán que John Ruskin fué tanto escritor como arquitecto y que su amor por la arquitectura está reflejado en muchas de sus bellas composiciones en prosa. A mi esposo le gustaba particularmente la siguiente cita de Ruskin: "... cuando construyamos, pensemos que construimos para siempre. Que no sea ello un placer momentáneo o nuestra construcción para uso únicamente del presente, sino un trabajo que nuestros descendientes nos agradezcan; y pensemos, cuando coloquemos piedra sobre piedra, que vendrá un tiempo en que esas piedras serán sagradas porque nuestras manos las han tocado, y que los hombres dirán al contemplar la labor y la substancia forjada a través del tiempo: "Mirad, esto es lo que nuestros padres hicieron por nosotros." Este pequeño prefacio lo he usado porque sintetiza la filosofía de mi esposo y nos ayuda a comprender por qué él, que se dedicaba a la creación y manejo de grandes empresas comerciales, hizo una donación tan considerable para que se usara en investigaciones agrícolas que beneficiarían tanto a otras empresas como a las suyas y aún sabiendo que los frutos de tales investigaciones talvez no podrían cosecharse durante su vida.

Nosotros contrajimos matrimonio un poco después que él recibió su título de abogado de la Universidad de Nebraska. En vez de practicar leyes, él decidió organizar una compañía de semillas y viveros. Unos años después de haber principiado esa compañía, se interesó tanto en la posibilidad de usar la radio como medio de propaganda, que construyó una estación de radio. Me gustaría tener tiempo suficiente para contar todo lo que pasó mientras estos dos negocios se extendían, pero ello sería muy largo. Hubo muchos problemas y contrariedades, hubo depresiones—años secos—años lluviosos—y dificultades por la longitud de las hondas para las estaciones de radio, pero todo se desarrolló bien y ahora La May Seed & Nursery Co., además del envío por correo de cientos de miles de catálogos, tiene una cadena de veintinueve tiendas de ventas al por menor en los estados de Iowa, Nebraska, Missouri y Kansas. La estación de radio KMA es una de las estaciones regionales del País más sobresalientes y varias veces le ha sido adjudicada una placa de Bronce, por ser la estación finquera más importante de los Estados Unidos. La May Seed & Nursery Co. y la estación KMA se han convertido en instituciones, por decirlo así, en nuestra sección de los Estados Unidos, a la cual llamamos el Medio Oeste. Mr. May tenía interés en comprender a la gente y se entregó a ello con afán. Además de su interés por la gente, Mr. May tenía un vivo interés por la agricultura. En sus viajes, estudió la agricultura del pueblo y buscó qué contribución podría dar a su propio estado y a otras regiones, y se convenció de que el clima

semi-tropical y tropical de las regiones de México y Centro América tenían mucho que contribuir para el mejoramiento de la agricultura.

Este fué como un desafío para Mr. May quien decidió hacer algo para promover el estudio de la agricultura, porque estaba convencido que tal estudio beneficiaría a las dos Américas, Central y del Norte. Con este fin visitó al Dr. Melhus, Dr. Friley y otros en Iowa State College y encontró en ellos el mismo entusiasmo que en él se había despertado. Se decidió que el estudio básico del maíz podría ser de gran beneficio para la agricultura y para comenzarlo, Mr. May donó \$75,000 como subvención al Iowa State College. Estoy orgullosa por la parte que mi esposo tomó en este asunto, y contenta al saber que mientras ésto se realiza, Guatemala y otros países de Centro América se están beneficiando por el incremento en la producción de sus tierras, tanto de maíz como de otros productos agrícolas, como resultados del trabajo que está llevando a cabo El Tropical Research Center en este hermoso, benévolo y cooperativo país de Guatemala.

La Cooperación En La Agricultura

POR EDWIN J. KYLE

EMBAJADOR DE LOS ESTADOS UNIDOS EN GUATEMALA

Los cuatro productos agrícolas de mayor importancia en el mundo como alimento, a juzgar por el número de hombres que dependen de ellos, son: el arroz, el trigo, las papas, y el maíz. Los cuatro se producen con éxito en Guatemala, dos de ellos, el maíz y las papas, se supone que son originarias de este país, en el que se puede producir gran cantidad de verduras, frutas, flores y otros productos agrícolas. Ha sido un placer y privilegio cooperar en todo lo que he podido para ayudar en la economía Agrícola de este país, introduciendo plantas y fertilizantes, estableciendo métodos de cultivo, ayudando a los estudiantes a lograr becas para su entrenamiento en colegios agrícolas de los E.E.U.U. etc. Con especial placer he tenido el privilegio de ayudar al Iowa State College en el importante y fundamental trabajo que está haciendo en Guatemala. Estoy convencido de que los resultados obtenidos en este trabajo probarán ser de gran valor y servicio para este país. Quiero también mencionar al Sr. Earl E. May, quien contribuyó con generosidad e hizo posible la creación de este centro de investigaciones agrícolas. Deseo presentar mis agradecimientos a su viuda, Señora Gertrude May, por su interés en este trabajo y su presencia aquí; también al Dr. Melhus y sus colegas quienes han logrado hacer de ésto una realidad y al Dr. Friley cuya dirección y cooperación en este importante Centro ha sido apreciada.

Recursos Vegetales En El Trópico Americano

POR I. E. MELHUS

DIRECTOR, TROPICAL RESEARCH CENTER

Es un gran placer tener como huéspedes de El Tropical Research Center, una reunión tan distinguida, porque ésta es una ocasión extraordinaria: la apertura oficial de una dependencia de una Institución Tecnológica en un país extranjero. Esto no había ocurrido antes en ninguna parte del Hemisferio Occidental. Hemos venido aquí inspirados por un deseo de mejoramiento social y económico no solamente para el estado de Iowa y la República de Guatemala, sino para el mundo entero. Nosotros escogimos trabajar en Guatemala por sus inmensos recursos en plantas inexploradas. Hoy, al final de la primera mitad del siglo 20, hay un déficit de alimentos debido al gran aumento de la población y la destrucción de miles de acres de tierra a causa de la erosión. El hambre es una amenaza a la Paz, a la seguridad y al bienestar de la humanidad.

Ya no hay extensas áreas inexploradas como habían en el siglo 19; queda solamente una gran área de tierra sin que sus recursos vegetales hayan sido explorados totalmente, y esa área está en el trópico. Parece razonable creer que si el trópico de América ha provisto al mundo en el pasado con muchas cosechas que lo alimentaron en gran parte, podrá hacer lo mismo en el futuro.

Esta riqueza virtualmente inexplorada, puede muy bien con sus recursos, cortar las fuerzas del hambre. Hoy no utilizamos los recursos vegetales de los trópicos con la ayuda de la ciencia en su primer estado de desarrollo, sino con dos siglos de descubrimientos científicos para fortalecernos. Como resultado, nosotros ahora vemos con ojos que ven más lejos, y trabajamos con herramientas más eficientes que en ningún otro tiempo en el pasado. Es con esta nueva visión y estas herramientas, respaldadas por los nuevos conocimientos, que todas las naciones deben otra vez explorar el trópico, con sus centros creadores de plantas. en busca de nuevos recursos que fueron inaccesibles y extraños al hombre primitivo.

No podemos predecir los resultados de nuestros estudios, pero sí estamos seguros de que serán de fundamental importancia no solamente para Guatemala sino también para los Estados Unidos. Estos descubrimientos no serán propiedad de ninguna nación: serán universales y servirán para el mejoramiento social de todos los pueblos. Esta fué la visión que tuvo Earl E. May, quien donó dinero en efectivo ayudando así a hacer posible la apertura oficial de este Centro dedicado al estudio y educación avanzada, El Iowa State College-Guatemala Tropical Research Center.

Cooperación De La Empresa Privada En El Mejoramiento Del Maíz

POR PEDRO G. COFINO

FINCA RETANA, ANTIGUA, GUATEMALA

El aumento de la producción de maíz es de importancia mundial, debido a sus múltiples usos como alimento y como materia prima para la industria. Es aún más importante para Guatemala por que aquí el maíz es la base de la alimentación de alto porcentaje de la población.

Como la mayor parte de nuestra producción está en manos de pequeños agricultores, las cosechas son malas, debido principalmente a la falta de selección de semillas y a los anticuados métodos de cultivo que se usan.

Es necesario hacer una selección científica y mejorar la semilla de maíz; investigar nuevos métodos para mejorar la fertilidad del suelo e impulsar el empleo de maquinaria agrícola. Tenemos también que aumentar la resistencia de la planta a las condiciones adversas del tiempo, a las enfermedades y plagas.

Estas mejoras en la semilla y en el cultivo habrán de reducir el costo de producción, de tal manera que será factible usar más el grano para alimentar ganado y aún para fines industriales. También mejorarán nuestra economía haciendo innecesaria la importación del maíz.

Yo creo que estas mejoras sólo pueden lograrse por medio de investigaciones científicas, aprovechando los trabajos avanzados que se han hecho ya en Estados Unidos y por este motivo considero de tanto interés el programa que desarrolla el Iowa State College, por medio del Guatemala Tropical Research Center, ya que éste sin duda ayudará a incrementar la producción de maíz en todo el mundo.

Las empresas privadas deben cooperar en estas investigaciones y, con su interés alentar los experimentos, permitiendo el uso gratuito de sus tierras, implementos y maquinaria agrícola y con fondos suficientes para lograr que las investigaciones continúen hasta que se logre un resultado satisfactorio.

Estoy seguro que con el interés que se demuestra ahora por los trabajos del Dr. Melhus y sus colegas, encontraremos medios de aumentar y hacer más efectiva nuestra cooperación.

Radio Program Announcing the Official Opening of the Iowa State College- Guatemala Tropical Research Center

PROGRAM OVER TGW RADIO NACIONAL DE GUATEMALA BY
SHORT WAVE TO THE AMERICAN FARMER SHOW OF ABC IN-
CLUDING KMA IN SHENANDOAH, IOWA, U.S.A., MARCH 6, 1948.

LANGFITT: This is Merrill Langfitt in Guatemala, the land of eternal spring, a beautiful little country in Mid-America, no larger in size perhaps than Iowa or other midwestern states, a country of 3½ million people, which boasts a rich, fertile soil and grows nearly every crop that is grown anywhere in the world. The native Guatemalan, 85 percent of which trace themselves to the early Mayan Indian civilization, is very friendly and the foreign traveller is treated with every courtesy as he visits the many interesting and picturesque parts of the country. As one travels from Puerto Barrios on the Atlantic coast to Guatemala City, the capital, he sees an interesting cross section of the agriculture and the people. Almost immediately after leaving Barrios our train winds its way through a dense jungle. In the jungle clearings one sees corn, beans, bananas and tobacco growing in adjacent fields. The parrots chatter and the lazy alligator swims or suns himself along the banks of the rivers. As midday approaches it becomes very hot in the lowlands, whereas the people living in the higher elevations are enjoying an approximate 60 or 70 degrees the year around. One is greatly impressed with the thrift and cleanliness of the people including the natives who live in thatched roof huts with only dirt for floors. Agriculture engages 90 percent of the Guatemalans, with coffee occupying one-fifth of the cultivated land, followed by bananas, sugar cane, corn, beans, wheat, cotton and tobacco. Our two-fold purpose in being here is to present an agricultural story and travelog to our KMA radio audience and, through the American Broadcasting Company and its affiliated stations, announce to the world the official opening of the Iowa State College-Guatemala Tropical Research Center. On our program today will be representatives of Guatemalan agriculture and guests from the States associated with the Iowa State College-Guatemala Tropical Research Center. Our first guest speaker is el Señor Ministro de Agricultura, Don Francisco Valdés Calderón.

CALDERON: Tengo el honor de dirigirme a los agricultores del gran pueblo Norte-Americano en nombre de los agricultores de Guatemala para que prosigamos cada vez más unidos, más juntos, extrayendolo a la madre tierra el jugo necesario para alimentar al mundo entero que hoy se convulsiona debido a falta de alimentos. Nosotros los soldados que laboramos la tierra debemos de cumplir esa misión y solo la podremos cumplir unidos, hombro a hombro, brazo a brazo, con los agricultores del gran pueblo Norte-Americano. El Gobierno de Guatemala también por mi medio saluda a todos vosotros soldados y así seguiremos siempre luchando por el bien de la humanidad labrando la tierra que Dios nos dió precisamente para cumplir esa sagrado misión.

LANGFITT: Thank you, Minister Francisco Valdés Calderón. We will now hear the gist of the Minister's remarks stated in English by Director General de Agricultura de Guatemala, Director Don Hector Sierra.

SIERRA: The Minister of Agriculture, Licenciado Coronel Francisco Valdés Calderón said it is a pleasure to have the opportunity to greet the American farmers, especially those in the Middlewest. We, farmers in Guatemala, extend our best wishes to all of you.

LANGFITT: Thank you, Director Don Hector Sierra. We are happy to have you on this broadcast today. Next we want to introduce Dr. I. E. Melhus, director of the Iowa State College-Guatemala Tropical Research Center, who will tell us about the Tropical Research Center.

MELHUS: The Tropical Research Center in Guatemala is an outgrowth of Iowa State College. This Center was started in 1945 for research and graduate study in agriculture and the natural sciences. Our purpose is to supplement the studies that are being carried on in our own fields and laboratories with similar studies here in the tropics where so many of our crop plants originated. All of this has been made possible largely through a grant of money from a public spirited citizen of Iowa, the late Earl E. May. Guatemala was chosen as the location for the Research Center because more of our crops originated here than in any other part of the world. Examples are some corns, beans, peppers, upland cotton, tomatoes, squash, sweet potatoes and many other crops. Guatemala is not far from the United States. It is the closest and most logical place for us to work in tropical America. Our first efforts were to study the corns in Guatemala and collect samples for later use. Some 500 collections were made. The next step was to grow these under as uniform conditions as possible in six different climatic zones in Guatemala. In this way we were able to detect the characteristics that might be the most useful to

us in the corn belt and in Guatemala. The first step consisted of crossing these desirable Guatemalan corns into our U.S. inbred. This permits us to move the desirable germ plasm back to the corn belt for comparative studies on our own experimental plots in Iowa.

LANGFITT: Is it possible, Dr. Melhus, that you might find characteristics which will help correct the large losses of corn from hot, dry weather such as we experienced in the Midwest last year?

MELHUS: As a matter of fact, Mr. Langfitt, we have already found strains that are heat and drouth tolerant and are crossing them into our corn belt hybrids. At Ames last year we grew 35 of these experimental hybrids that tolerated the heat and drouth better than the U.S. commercial hybrids. They came through with a full set of green leaves and matured good ears before frost. The U.S. hybrids which we used as checks fired and died before frost. In addition several of these Guatemalan-U.S. crosses yielded along with three of the commonly used corn belt hybrids. Not only can we bring to the corn belt more heat and drouth tolerance, but also resistance to disease, insects, cold, etc. by selecting for those characteristics and crossing them into our corn. Similar research techniques can be applied to legumes and other crops that have originated in Middle America.

LANGFITT: Dr. Melhus, we have talked of the possible benefits of this research program to the American farmer. What might your studies mean to the agriculture of Guatemala?

MELHUS: The benefits to tropical America are inevitable. First, we are isolating the highest yielding varieties that exist in Guatemala. The seed supply is being purified and increased for distribution this year. Second, we are helping to develop a system of rotation including legumes and green manure. This will improve the soil fertility and the tilth. Third, we are encouraging the use of modern machinery instead of hoe culture, and fourth, we are endeavoring to protect the crop from disease and insects during its growth and development in the field and storage after harvest.

LANGFITT: Well, Dr. Melhus, you certainly have an ambitious program. We are sure that as one of America's leading plant scientists you will be very successful, and that your program will result in great benefit to all of the people of the Western Hemisphere. We have the pleasure now of presenting Mrs. Gertrude May, vice president of the May Seed Company in Shenandoah, Iowa. Mrs. May, I am sure our American farmers would like to know of the interest your husband had in the agriculture and the people of Central America.



Mrs. Gertrude W. May represented the May Seed Company and Radio Station KMA, Shenandoah, Iowa, in the short wave broadcast from Guatemala City to the American Broadcasting Company in Chicago, Ill. This program was dedicated to Mrs. May.

MRS. MAY: Mr. May was an advocate of Pan Americanism. He visited Mexico City, Veracruz, Taxco, Acapulco, Guadalajara, and many other points of interest several times. He was impressed with the climate, the flowers, the crops and the people. He talked with folks from all walks of life, from taxi drivers to high ranking government officials. Through these visits in Mexico he became interested in all of Latin America, and came to realize the opportunities that lie in cooperation between the countries of this hemisphere. This was a challenge to Mr. May's keen visionary power. He saw the potentialities of agricultural research in this re-

gion. Because the leading crop of the Americas is corn and because Mr. May was a farm-minded leader from the corn belt of the United States, it was natural that he directed his attention to the possibility of the improvement and development of corn. He knew that corn is said to have originated in this part of the world, and he learned that hundreds of varieties and strains grown here for century after century would furnish strains with varying characteristics that could be combined with the corns of the United States to produce corn that would far surpass those of our present hybrids. With these thoughts in mind, my husband, the late Earl E. May, offered a financial grant to Iowa State College, which they accepted and this Tropical Research Center is now a reality. Under the able direction of Dr. Melhus, wonderful progress has already been made; many selections of Central American corn are being tested, purified and crossed with corn in the United States. Performance is being compared with our present hybrids, the results are most encouraging. Much work remains to be done, but I am confident that in the not too distant future Iowa State College and the Tropical Research Center will be releasing inbred lines with valuable Guatemalan characteristics. I am proud of the part my husband had in bringing this about, and I am happy in the knowledge that while this is taking place, Guatemala and the other countries of Central America will also be benefiting through increased yields of corn and other crops as a result of the work being done at the Tropical Research Center in this beautiful, friendly and cooperative country of Guatemala.

LANGFITT: Mrs. May, we feel confident that the hopes and desires of your husband, the late Earl E. May, will be realized as the work of the Tropical Research Center progresses. We are happy that you could be here in Guatemala for the opening ceremonies. I am happy to announce that private enterprise is already cooperating with the Tropical Research Center and we have here today A. L. Bump, manager of the Compania Agricola de Guatemala (a branch of the United Fruit Company) located on the Pacific slope at Tiquisate. Mr. Bump, will you tell us the ways in which your company is cooperating with Dr. Melhus in his corn breeding program?

BUMP: Dr. Melhus has one of his experimental plots at Tiquisate. The company supplies the land, most of the labor, and Dr. Melhus supplies most of the technical knowledge. However, we have problems of our own on which the boys from Iowa give us a lot of help. One of the most important of these is in the mechanical cultivation of corn and other grains. They are helping us on the choice and operation of machinery, and thanks to the corn breeding program, we are certain to have corn that will be fit for mechanical cultivation and which will give at least 50 percent more production per acre than the present average in Guatemala.

LANGFITT: How important, Mr. Bump, has been the corn production in this country to the people all over this area? '

BUMP: It is pretty well known that corn is the most valuable single crop produced in the United States, but it is not so well known that it is much more important in Central America and Mexico. Many authorities believe that the plants we now know first developed in the regions close to the Mexican-Guatemalan border which is the only place in the world today where undomesticated relatives of corn grow wild. It is also generally accepted that as long ago as 1,000 years before the birth of Christ, corn was the most important single item in the life of the Mayan Indian, the ancient inhabitant of this region. It was the essential base of his religion. According to mythology, the first man and woman, the Adam and Eve of the race, sprang from an ear of corn. Problems of preparing land, the planting, the cultivating and harvesting of the crops occupied the bulk of conversation. Some of the most important religious ceremonies mark the days when these agricultural operations should be done. Furthermore, since there were no strongly marked seasons, his calendar was devised primarily from the Farmer's Almanac. It was formed after many years of careful astronomical observations, with the result that the Mayan calendar of 1200 years ago is slightly more accurate than the calendar we use today. The importance of corn has a sound material basis as it comprised 80 percent of the diet of these ancient people. In fact, corn alone served as large a place in the diet of the Mayan peoples as corn, wheat and potatoes combined do in the diet of the people of the United States today.

LANGFITT: You talked about the importance of corn down through the ages, Mr. Bump. How important is corn today?

BUMP: Although the ancient temples are in ruin, the importance of corn lives on. An instinct for its culture remains in the hearts and minds of the descendants of the Mayans, and it is as important a food as ever. In Mexico and Central America there are probably more than 25 million people whose diet is still 80 percent corn. To these people a good crop means that food is plentiful while a poor crop brings hard times, starvation and political and economic unrest. The work now being carried on by Dr. Melhus and his group of experts from Iowa State College cannot but help increase the food supply of this important region and anyone should be proud to be even remotely connected with that program.

LANGFITT: Thank you very much, Mr. Bump. Our final guest is Dr. Charles E. Friley, president of Iowa State College, who has been visiting here in Guatemala. Dr. Friley, I think our listeners back in the States would like very much to know the relation of research in the tropics to research in the States.

FRILEY: I think that is a very good question, Mr. Langfitt. The research program of the Tropical Research Center is complementary to the notable program of research on corn and other crops which we have been carrying on for many years in the Midwest and other parts of the United States. Our activities here in Guatemala are directed primarily to a study of those aspects of corn which are not common in the United States, and we have found, as Dr. Melhus indicated, many characteristics, some of which we believe will be of tremendous value to our corn in the United States.

LANGFITT: As I understand your comments, Dr. Friley, your research post here is really a supplementary program to the work going on in the States. What about the practical applications of the research program that is being carried on here in Guatemala to the agriculture of the Middlewest?

FRILEY: Well, again, corn is the most important crop in the Middlewest, and it is unquestionably true that as a result of our researches, we will be able in time to find characteristics that will improve the quality and we believe in some aspects the quantity of our corn production, and those are two of the very important phases of our work. In addition we are looking into the matter of insect resistance and drouth resistance as Dr. Melhus has indicated. These are all economic benefits which we believe will be of major importance.

LANGFITT: Is it not possible, Dr. Friley, that all of these things can mean a better standard of living for the farmers of the Middlewest, thereby better living for all of the people of all the world?

FRILEY: That is a natural outcome. The more agricultural prosperity, the more prosperous will be our people, both economically, socially and, I think, spiritually. In closing I want to say that I do not think we could have attained the excellent results that we have in the last three years if it had not been for the unselfish and intelligent cooperation of the Guatemalan government, particularly through the Ministry of Agriculture and its excellent staff. So to the Guatemalan government, the Minister of Agriculture and the Director General of Agriculture we offer our deep appreciation and gratitude.

LANGFITT: Thank you very much, Dr. Friley, for your excellent comments, and I wonder if you would now officially declare the Iowa State College-Guatemala Tropical Research Center open.

FRILEY: I shall do it in this way: The Iowa State College-Guatemala Tropical Research Center was officially opened with impressive ceremonies on Friday morning, March 5, at the headquarters of

the Center in Antigua. More than 60 distinguished representatives of agriculture were present from Central and South American countries and from the United States.

LANGFITT: Thank you again, Dr. Friley. The dream of one of Iowa's leading public-spirited citizens is now a reality, and this broadcast has served as an announcement to the world of the opening of the Iowa State College-Guatemala Tropical Research Center located in Antigua, here in this fascinating country of Guatemala.